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6420 Indexer/Drive
User Manual

MA6420
Rev C

Record of Manual Revisions

ISSUE	Date	Description of Revision
A	07/1992	Initial release
B	07/1996	Updated corporate information
C	10/2003	Updated corporate information

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- The safety-alert symbols used in this manual are:

Warning Alerts users to potential physical danger or harm. Failure to follow warning notices could result in personal injury or death.

Caution Directs attention to general precautions, which if not followed, could result in personal injury and/or equipment damage.

Note Highlights information critical to your understanding or use of the product.

Table of Contents

1. OVERVIEW OF 6420 INDEXER/DRIVE 1
1.1. 6420 DEFINITION 1
1.1.1. BLOCK DIAGRAM 2
1.1.2. FIXED RESOLUTION MODE 2
1.1.3. VARIABLE RESOLUTION MODE 3
1.2. DRIVE FEATURES 3
1.3. INDEXER FEATURES 4
1.4. SYSTEM COMPONENTS 4
1.5. WARRANTY 4
2. INSTALLING THE 6420 INDEXER/DRIVE 5
2.1. UNPACKING AND INSPECTING 5
2.2. MOUNTING THE 6420 5
2.2.1. MOUNTING DIMENSIONS 6
2.3. CONNECTING THE FOUR INPUT/OUTPUT CABLES 6
2.3.1. CONNECTION DIAGRAM 7
2.3.2. J3 MOTOR CONNECTION 7
2.3.2.1. 4-Lead Motor Cable Requirements 8
2.3.2.2. 8-Lead Motor, Series Connected 9
2.3.2.3. 8-Lead Motor, Parallel Connected 10
2.3.3. J2 - POWER CONNECTION 10
2.3.4. J4 - SERIAL PORT CONNECTION 11
2.3.4.1. Single-unit RS-232 Connection 12
2.3.4.2. Single-unit RS-422 Connection 12
2.3.4.3. Multi-unit RS-485 Connection 13
2.3.5. J5 - DISCRETE INPUTS/OUTPUTS CONNECTION 13
2.3.5.1. Dedicated Discrete Input/Output Lines 15
2.3.5.2. Input Interface Suggestions 17
2.3.5.3. Output Interface Suggestions 18
2.4. USING THE 6420 TO CONTROL A 6410 DRIVE 18
2.4.1. SYNCHRONOUS OPERATION 19
2.4.2. ALTERNATING OPERATION 19
2.5. FACTORY DEFAULT SETTINGS 19
2.5.1. DRIVE 19
2.5.2. INDEXER 20
2.5.3. DRIVE BOARD SETTINGS 20

2.5.4. INDEXER BOARD SETTINGS 21
2.5.4.1. Jumper Settings 21
3. POWERING UP THE 6420 23
3.1. TESTING THE INSTALLATION 23
4. MAINTAINING\TROUBLESHOOTING 25
4.1. MAINTAINING THE 6420 25
4.2. TROUBLESHOOTING THE 6420 25
5. PROGRAMMING AND INSTRUCTION SET 27
5.1. IMMEDIATE MODE 27
5.2. EXECUTION MODE 28
5.3. THE AUTOSTART PROGRAM 28
5.4. INSTRUCTION OVERVIEW 28
5.4.1. MOTION CONTROL 29
5.4.2. PROGRAM CONTROL 29
5.4.3. PARAMETER INITIALIZATION 29
5.4.4. INITIALIZATION AND UTILITY COMMANDS 29
5.5. MEMORY MAP 29
5.5.1. USER PROGRAMS 29
5.5.2. FAST RAM 30
5.5.3. MEMORY MAP DETAILS 30
6. 6420 DIALOGUE 31
6.1. GETTING STARTED 31
6.1.1. USING THE 6420 DIALOGUE FLOPPY DISK 31
6.1.2. INSTALLING 6420 DIALOGUE ON A HARD DRIVE 32
6.1.3. SERIAL PORT CONNECTIONS 32
6.1.4. KEYBOARD COMMANDS 32
6.1.5. TERMINAL EMULATOR 33
6.1.6. UPLOAD UTILITY 33
6.1.7. DOWNLOAD UTILITY 33
6.1.8. SYNTAX CHECKER 33
6.1.9. EDITOR 34
6.1.10. INIT SERIAL PORT 35
6.2. INDEXER LANGUAGE 36
6.2.1. SYMBOLIC LABELS IN PROGRAMMING 36
6.2.2. SYNTAX CHECKER 37
6.2.3. ADDRESS TRANSLATION OF LABELS 37

6.2.4. LABEL GENERATION FOR ADDRESSES 38

7. PROGRAMMING INSTRUCTIONS 39

APPENDIX A SPECIFICATIONS 73

FIXED RESOLUTION MODE 73
VARIABLE RESOLUTION MODE 74
COMMUNICATIONS 74
MULTI-AXIS CAPABILITY 74
PROGRAMMING 74

APPENDIX B ORDERING INFORMATION 77

APPENDIX C QUICK REFERENCE 79

APPENDIX D RAMP ALGORITHM & LOOKUP TABLE 81

DIVIDE COMMAND 82
SPEED ACCURACY 84

APPENDIX E APPLICATION EXAMPLES 85

STANDALONE OPERATION 85
HOST OPERATION SINGLE UNIT 86
HOST OPERATION MULTIPLE UNITS 87
PLC BASED CONTROL 88
6420 DISPENSING PRODUCT ONTO CONVEYER BELT 88
6420 CONTROLLING INDEXER TABLE 89
MISCELLANEOUS APPLICATION NOTES 90

APPENDIX F ASCII CODES 93

APPENDIX G POWER SUPPLY CONSIDERATIONS 95

BRIDGE, CAPACITOR POWER SUPPLY 95
LINE TRANSFORMER SELECTION 96
RECTIFIER DIODE SELECTION 98
CAPACITOR SELECTION 98
FUSE SELECTION 99
REGENERATION CONSIDERATIONS 99
POWERING THE 6420 FROM A REGULATED SUPPLY 101
6420(S) POWERED BY REGULATED SUPPLY 102

INDEX 103

1. OVERVIEW OF 6420 INDEXER/DRIVE

This section introduces the 6420 Indexer/Drive. Topics covered are:

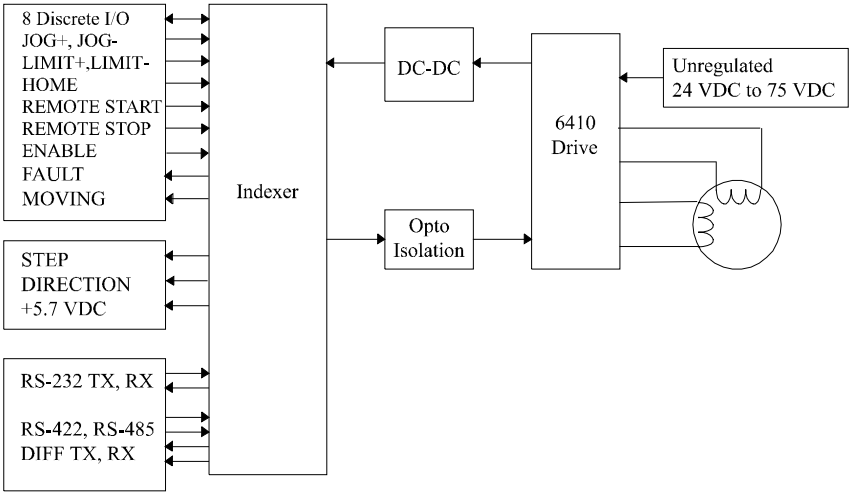
- 6420 definition
- System diagram
- Warranty information

1.1. 6420 DEFINITION

The 6420 Microstepping Indexer/Drive provides economical microstepping control with a simple mnemonic programming interface. Operation is programmed via the serial communications port. A combination of dedicated and user-programmable I/O provides motor control, status indication and sensor feedback.

Simple, single-letter mnemonics specify a wide variety of motion commands. Use a terminal or PC with terminal software to familiarize yourself with 6420 operation. Various motion parameters are modified and motion executed immediately from the command line or from on-board non-volatile memory. Many applications take advantage of the simplicity of developing programs for on-board execution. If more versatility is required, you can write a custom program running on a host computer issuing immediate motion commands to the 6420.

1.1.1. BLOCK DIAGRAM



The 6420 communicates with RS-232, RS-422 or RS-485 serial protocols. Discrete I/O lines provide external start/stop and motor enable control, home and limit switch testing, motor jogging, slave drive interface and eight programmable bi-directional discrete I/O lines. The eight programmable bi-directional discrete I/O lines are individually jumper-configurable for input or output. Immediate command line instructions read back and write all eight bits.

1.1.2. FIXED RESOLUTION MODE

The unit operates in one of two modes, either Fixed Resolution Mode or Variable Resolution Mode. In Fixed Resolution Mode with binary steps, the resolution is set from 200 steps/rev to 51,200 steps/rev and with decimal resolution 200 steps/rev to 50,000 steps/rev. The minimum and maximum step rate ranges from 0.08 to 19,000 steps/sec, depending on the resolution.. The finer step sizes result in high shaft resolution at the expense of shaft speed. The motion profile is trapezoidal with programmable initial and final speeds. The acceleration and deceleration rates are specified by a single command in terms of acceleration and deceleration factors ranging from 1 to 255.

1.1.3. VARIABLE RESOLUTION MODE

Variable Resolution Mode is the recommended where micro-stepping is desired without compromising speed. This mode allows for positioning at a resolution of 1/100 of a step at effective full step speeds of 20-19,000 steps/second.

1.2. DRIVE FEATURES

Internal power supply - Single power supply

Bipolar chopper drive - Patented for superior current regulation and low ripple current.

Output current - Adjustable from 0.625 A to 5 A_{RMS} with 3 position DIP switch.

Microstepping - Smooth operation and increased resolution.

Fixed Resolution microstepping - Binary Steps: Full, 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256. Decimal Steps: Full, 1/2, 1/5, 1/10, 1/25, 1/50, 1/125, 1/250

Variable Resolution microstepping - Decimal step resolution 0.01 steps at effective full step speeds of 20-19,000 steps/second

Optical isolation - Indexer optically isolated from drive

Digital Electronic Damping - Patented circuit reduces instability at speeds in middle of operating range.

Idle Current Reduction (ICR) - Reduces motor heating in many applications

Fault protection - Line-to-line and line-to-neutral shorts, Internal power supply under-voltage, Bus overvoltage

Small size - Only 7.5 square inches of panel space.

UL Recognized - 508C (Type R) - File E-137798. Complies with CSA Standard for Process Control Equipment, C22.2 No. 142-M1987.

Vibration - IEC Standard 68-2-6.

1.3. INDEXER FEATURES

Simple mnemonic command set - Executed from either internal NVRAM or from a more powerful host.

Serial port communications - Supports RS-232, RS-422 and RS-485 multi-drop.

Multi-axis - Single 6420 can control two independent or synchronous axes with an additional drive and no glue logic.

Input/Output ports - Eight general purpose bi-directional user programmable input/output ports.

Internal Memory - Approximately 1792 bytes of non-volatile memory are available for user programs.

1.4. SYSTEM COMPONENTS

The other components that, along with the drive, comprise a complete motor control system are:

- Single Power Supply (24 - 75 VDC)
- Motor

Installation guidelines for these components are described in *Installing the 6420 Indexer/Drive*.

1.5. WARRANTY

Danaher Motion's Pacific Scientific 6420 Indexer/Drive has a two year warranty against defects in material and assembly. Products modified by the customer, physically mishandled or otherwise abused through miswiring, incorrect switch settings, etc., are exempt from the warranty plan.

2. INSTALLING THE 6420 INDEXER/DRIVE

This section explains how to install the 6420 Indexer/Drive. Topics covered are:

- Unpacking and inspecting the 6420
- Installation of motor, power, discrete I/O and serial communications cables
- Configuration of drive, indexer jumpers and DIPswitch
- Heat sink requirements and power supply filter capacitor

2.1. UNPACKING AND INSPECTING

1. Remove the 6420 from the shipping carton. Make sure all packing materials are removed from the unit.
2. Check the items against the packing list. A label located on the unit identifies the unit by model number, serial number and date code.
3. Check items for damage. If you find any damage, concealed or obvious, promptly contact your buyer to make a claim with the shipper.
4. Store the 6420 in a clean, dry place, preferably in the original shipping carton.

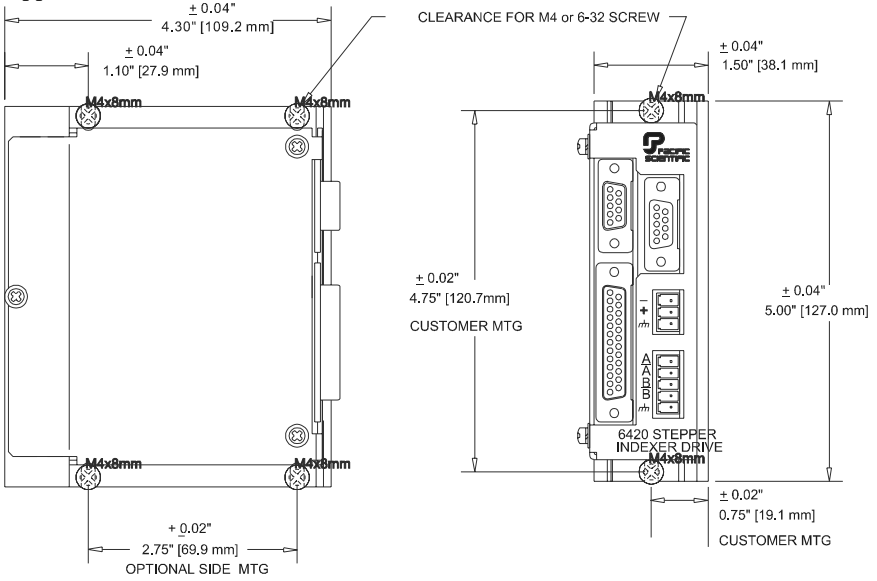
2.2. MOUNTING THE 6420

Select a standard 8-inch (205 mm) deep NEMA (National Electrical Manufacturers Association) enclosure appropriate for industrial applications.

The internal operating temperature should not exceed 50°C. If the cabinet is ventilated by filtered or conditioned air, make sure to prevent the accumulation of dust and dirt on the unit's electronic components. The air should also be free of corrosive or electrically conductive contaminants.

2.2.1. MOUNTING DIMENSIONS

The 6420 can be mounted in the two orientations shown below. Refer to Appendix A for additional information.



2.3. CONNECTING THE FOUR INPUT/OUTPUT CABLES

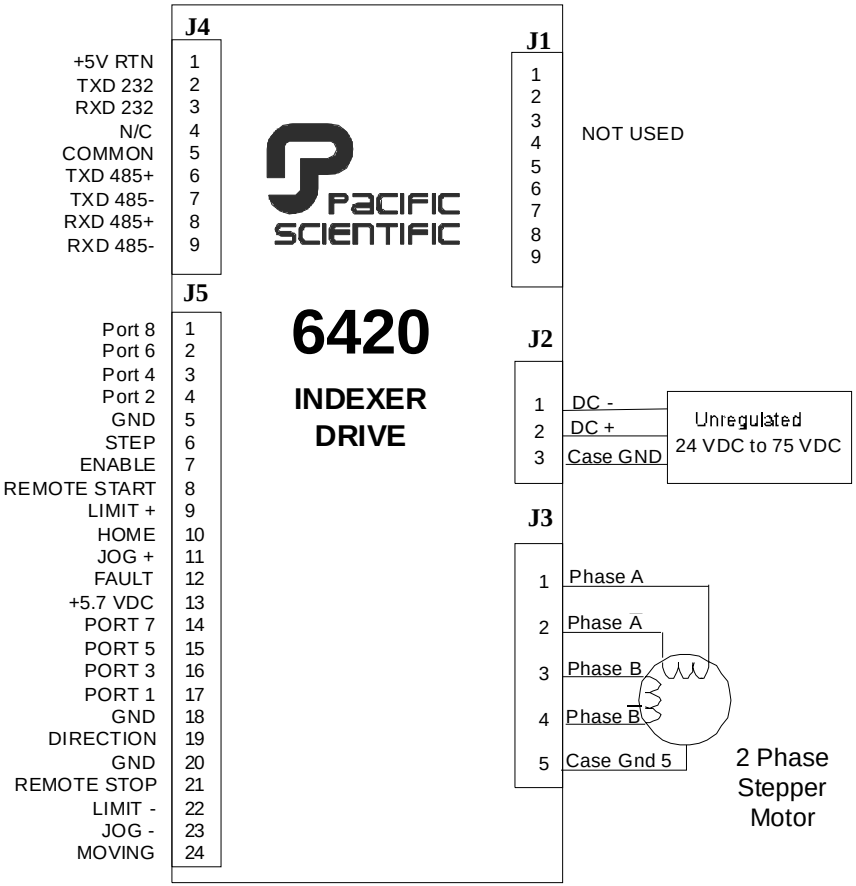
The four input/output cables are:

- J3 - Motor
- J2 - Power
- J4 - Serial port
- J5 - Discrete inputs and outputs

J1 Connector is NOT USED.

2.3.1. CONNECTION DIAGRAM

The inputs and outputs are:



2.3.2. J3 MOTOR CONNECTION

The J3 motor cable connects the drive to the motor windings. Motor cables are available from Danaher Motion or you can make your own.

The J3 motor connector is for a PCD 5-pin screw mating connector. The mating connector, supplied with the unit, is type ELVP05100.

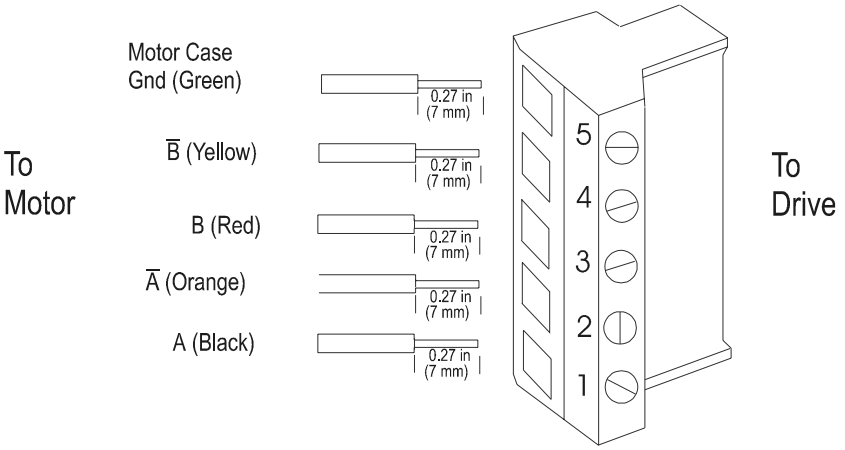
2.3.2.1. 4-LEAD MOTOR CABLE REQUIREMENTS

Use 18- to 16- gauge stranded wire, twisted at approximately 3 to 4 turns per inch for each motor phase.

Building A 4-Lead Motor Cable

The motor cable assembly uses a 5-pin PCD connector at the 6420. Danaher Motion Pacific Scientific motors commonly use a MS style connector at the motor end. The cable assembly using standard Danaher Motion stepper motor color coding is shown below:

Cabling Diagram



1. Strip the wires to 0.27 inch (7 mm).
2. Attach the wire to the connector as indicated in the diagram.

Do not pre-tin (solder) the tops of the cables going into the PCD connector. This can result in a loose connection.

Make sure the screws on the PCD connector are tightened down firmly to the wiring.

3. Remove power from the 6420.

Always remove power before making or removing connections to the unit. The motor terminals have high voltage present when the 6420 is On.

4. Plug the mating connector firmly into the 6420.
5. Connect the cable shield to 6420 ground, if applicable.
6. Plug the other mating connector into the motor.
7. Switch On the 6420.

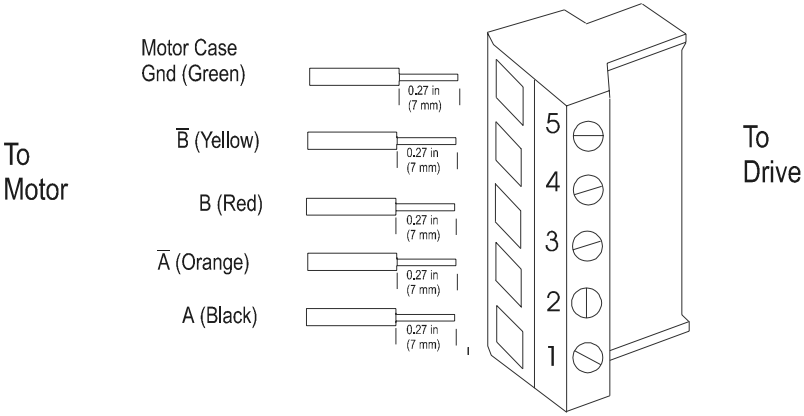
2.3.2.2. 8-LEAD MOTOR, SERIES CONNECTED

For an 8-lead motor to be wired in series, build and install the cable as described below.

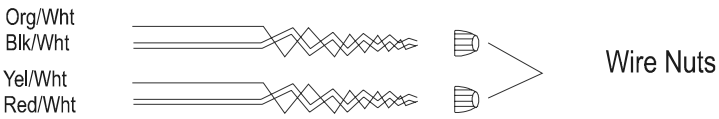
Building an 8-Lead Series Motor Cable

The connector assembly using standard Danaher Motion stepper motor color coding is shown below.

Cabling Diagram



In addition, make the following connections at the motor:



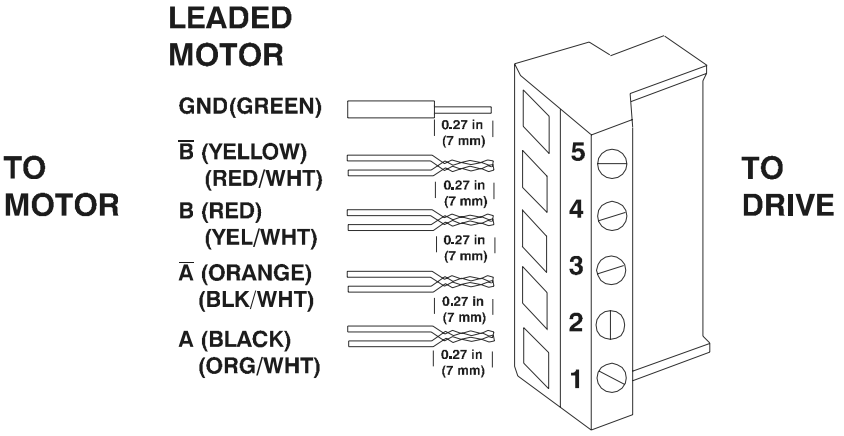
2.3.2.3. 8-LEAD MOTOR, PARALLEL CONNECTED

For an 8-lead motor to be wired in parallel, build and install the cable as described below.

Building an 8-Lead Parallel Motor Cable

The connector assembly using standard Danaher Motion stepper motor color coding is shown in the following cabling diagram.

Cabling Diagram



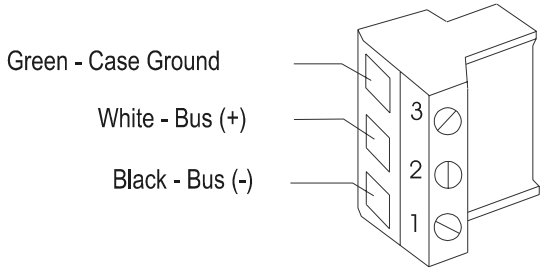
2.3.3. J2 - POWER CONNECTION

Bus power is applied to the 6420 J2 with a 3-pin PCD connector as shown on the following page.

Mating Connector

The J2 power input is for a PCD 3-pin mating connector. The connector, supplied with the unit, is type ELVP03100.

Cabling Diagram



2.3.4. J4 - SERIAL PORT CONNECTION

The serial port transmits and receives RS-232 communication for the user interface of your unit.

Mating Connector

The J4 serial port mating connector, supplied with the unit, is an ITT Cannon DE-9S 9-pin plug-in female D connector.

Port Connections

These are the RS-232 transmit (TXD) and receive (RXD) terminals.

Pin Number	Connection
J4-2	RS-232 TXD (output)
J4-3	RS-232 RXD (input)
J4-5	RS-232 Common

Baud Rate

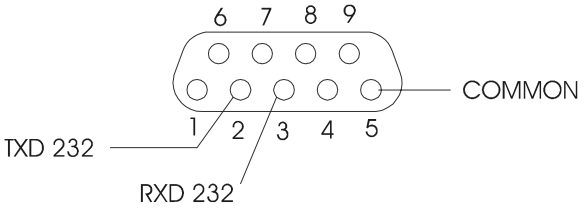
The 6420 supports single-unit RS-232, RS-422 and multi-unit RS-485 communication protocols running at 9600 bps, 1 start bit, 1 stop bit. RS-232 and RS-422 mode selection is automatic dependent upon whether connections are made to the single-ended RS-232 TX and RX lines or to the differential TX and RX lines. RS-485 mode is jumper selected and allows up to 32 units on a single differential RS-485 communications link. The host computer is the bus master and always initiates packet transfers. External termination may be required in some installations. The unit is factory configured for RS-232 protocol.

The table below shows the serial port pin designations.

Input/Output	Pin Number	Description
+ 5 VDC RTN/Shield	J4-1	
TXD_232	J4-2	RS-232 Transmit data (output)
RXD_232	J4-3	RS-232 Receive Data (input)
COMMON	J4-5	
TXD_485 +	J4-6	Differential Transmit Data (output)
TXD_485 -	J4-7	Differential Transmit Data (input)
RXD_485 +	J4-8	Differential Receive Data (output)
RXD_485 -	J4-9	Differential Receive Data (input)

2.3.4.1. SINGLE-UNIT RS-232 CONNECTION

Solder connections to TXD_232 (output), RXD_232 (input) and COMMON. After installing the power and serial communications cable, quickly test the unit by applying power, pressing <Esc> and the space bar. You should see the sign-on message and copyright notice.



2.3.4.2. SINGLE-UNIT RS-422 CONNECTION

Solder connections to TXD_485± and RXD_485 ± differential lines. After installing the power and serial communications cable, quickly test the unit by applying power, pressing <Esc> and the space bar. You should see the sign-on message and copyright notice.

Build the cable to connect to your computer or terminal by referring to the documentation for the device.

Pinouts vary among computer manufacturers. Check your computer's hardware reference manual before wiring.

2.3.4.3. MULTI-UNIT RS-485 CONNECTION

Solder connections to TXD_485± and RXD_485 ± differential lines. This mode requires each 6420 to be initialized with a single-letter node address to be used with each subsequent command. This node address must be setup in single-unit mode before the RS-485 mode operation is attempted. To set this address:

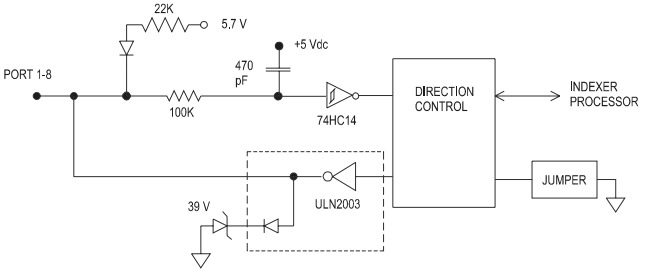
1. Apply power and press a key (a-z, A-Z) *NOT* the Spacebar, to be used as the address followed by a single space. Execute the P command to program the node address into non-volatile memory.
2. Power-down the unit and insert jumper E11 to configure the unit for RS-485 mode. There is no sign-on procedure while in RS-485 multi-unit mode. This mode is designed to be used with a host computer, but can be tested using a terminal.
3. Type in the node address. The character should be echoed if the unit recognizes the address.
4. Type a simple motion command, R 500 followed by a <LF> (line feed) terminating character (press <Ctrl> <J>). The motor should run.

Units configured for single-unit RS-232 or RS-422 always have the serial drive lines enabled. Therefore, avoid connecting one of these units into a chain of RS-485 configured units.

2.3.5. J5 - DISCRETE INPUT/OUTPUT CONNECTION

The 6420 features 8 user-programmable discrete input/output lines. Input/output selection for ports 1 to 8 is configured by jumpers E3 to E10, respectively. To enable a port as an input, remove the respective jumper. To enable as an output, install the jumper. Always remove the external cabling when making I/O configuration changes to ensure that an external low impedance input is not driving an I/O port configured as an output The block diagram of a single I/O bit is shown in the next figure.

Block Diagram



Inputs accept 0-30 VDC max, where Vin ≤ .8V is a logic low and Vin ≥ 3.7 V is a logic high. All outputs are Open Collector 30 VDC, 70 mA sink, Vsat ≤ 1.0V. All I/O signals are active low.

If a bit is desired to be an input, the jumper must be out and an inactive level (low) written to the bit using the Y command. Otherwise, as a consequence of the wired "AND" design of the indexer, a logic "1" written to a bit configured as an input will always be read back as a "1." Programs executing from non-volatile memory can only output to these discrete bits, reading is not allowed.

J5 Port Designations

The J5 connector pin designations are shown below:

Port	Pin Number	Jumper	I/O
1	J5-17	E3	Input 1 OR Output 1
2	J5-4	E4	Input 2 OR Output 2
3	J5-16	E5	Input 3 OR Output 3
4	J5-3	E6	Input 4 OR Output 4
5	J5-15	E7	Input 5 OR Output 5
6	J5-2	E8	Input 6 OR Output 6
7	J5-14	E9	Input 7 OR Output 7
8	J5-1	E10	Input 8 OR Output 8
GND	J5-5	N/A	Ground return for I/O signals.
GND	J5-18		
GND	J5-20		

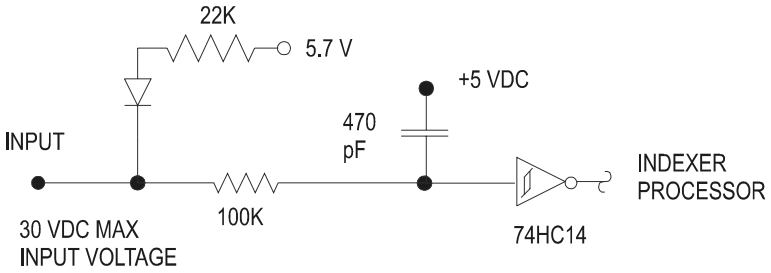
The Discrete I/O connector has its own ground points, completely isolated from the unit's bus power.

The minimum requirement to operate the unit is to enable motor current by connecting J5-7 (ENABLE) to one of the three J5 ground points (J5-5, J5-18, or J5-20).

2.3.5.1. DEDICATED DISCRETE INPUT/OUTPUT LINES

The 6420's operation is controlled by several input lines. These lines are active low. Input lines are RC filtered and passed to a 74HC14 Schmidt Trigger. The block diagram of input and output lines are shown below.

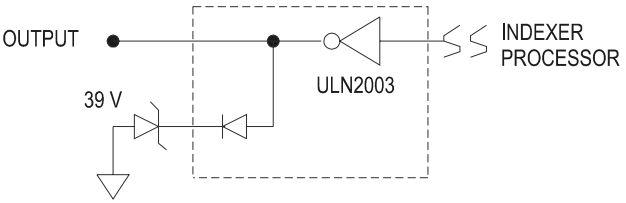
INPUT



Inputs accept 0 - 30 VDC max, where Vin ≤ 0.8 V is a logic low and Vin ≥ 3.7V is a logic high.

The 6420's outputs are open-collector Darlington ULN2003 drives. Inductive kick-back protection is provided by the built-in diode and 39 V Zener diode.

OUTPUT



All outputs are Open Collector 30 VDC, 70 mA sink, Vsat ≤ 1.0V. All I/O signals are active low.

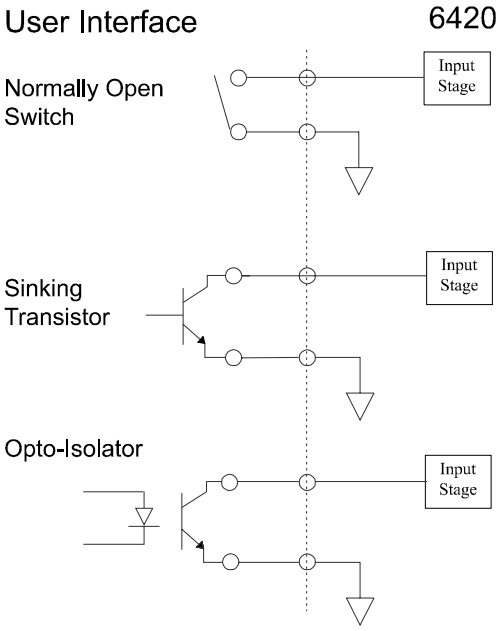
Dedicated Input/Output Pin Designations - J5

The pin definitions for all 6420 control lines are shown below:

Input/Output	Pin Number	Description
Remote Start	J5-8	This input activates program at location zero.
Remote Stop	J5-21	This input halts 6420 program and motion.
LIMIT +/LIMIT -	J5-9, J5-22	Activation of Limit + prohibits motion in CW direction. Activation of Limit - prohibits motion in CCW direction.
Home	J5-10	A transition at this input defines the electrical home position.
JOG +/JOG -	J5-11, J5-23	These inputs manually step the motor in the CW and CCW direction.
ENABLE	J5-7	This input is an active-low motor drive enable.
STEP	J5-6	This output is an active-low step pulse to slave drive approximately 400-600 ns in duration. Only in Fixed Resolution Mode.
DIR	J5-19	This output provides direction to slave drive. CCW is a logic low, CW is a logic high. Only in Fixed Resolution Mode.
+5.7 V	J5-13	This output provides power for slave STEP and DIR when used with a 6410 drive.
FAULT	J5-12	The output is an active-low fault indicator. It must be cleared by powering down.
MOVING	J5-24	This output is an active-low motion indicator.
GND	J5-20	Indexer ground, isolated from drive ground.

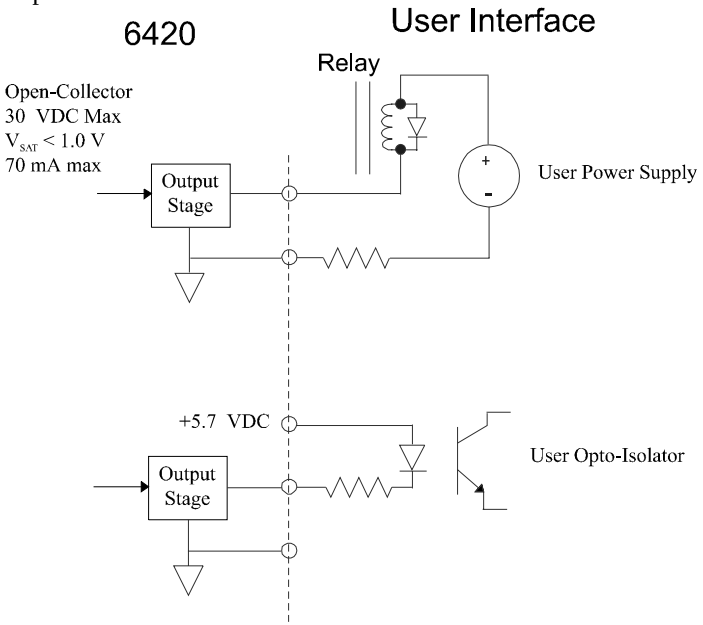
2.3.5.2. INPUT INTERFACE SUGGESTIONS

These are examples of driving regular inputs and I/O pins configured as inputs. The input lines pull down to ground and the internal 22 kΩ resistor through a 1N914 diode pulls up to 5.7 VDC. The input is designed such that the user can actively drive the inputs with a low impedance source from 0 to 30 VDC.



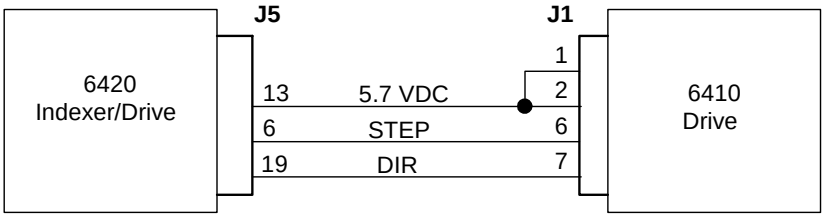
2.3.5.3. OUTPUT INTERFACE SUGGESTIONS

The output stage is a Darlington sink to ground. The user generally supplies the +V power. However, the 6420 can provide upto 200 mA from the 5.7 VDC intended for the slave 6410 interface, for applications such as driving 5-volt nominal Opto 22 devices.



2.4. USING THE 6420 TO CONTROL A 6410 DRIVE

A single 6420 can be used to control two axes in either synchronous or alternating fashion. The 6420 Indexer/Drive must be in fixed resolution mode. The slave 6410 drive is usually set for the same step resolution but does not necessarily have to be. Jumpers E12 and E13 are used to configure these modes.



2.4.1. SYNCHRONOUS OPERATION

E12 OUT, E13 IN
The T command, with enb = 1 enables step pulses to both master and slave. Issuing T with enb = 0 disables step pulses to both master and slave.

2.4.2. ALTERNATING OPERATION

E12 IN, E13 OUT
The T command, with enb = 1 enables step pulses to the master and disables the slave. Issuing T with enb = 0 disables the master and enables slave.

Do not insert both E12 and E13 at the same time.

All slave 6410 jumpers and DIP switches must be properly set. See the 6410 Data Sheet for additional information.

2.5. FACTORY DEFAULT SETTINGS

The 6420 unit is a two-board assembly incorporating a drive and an Indexer card set. With the cover removed, the topmost visible board is the Indexer. The Indexer mounts on the drive board and separated by standoffs.

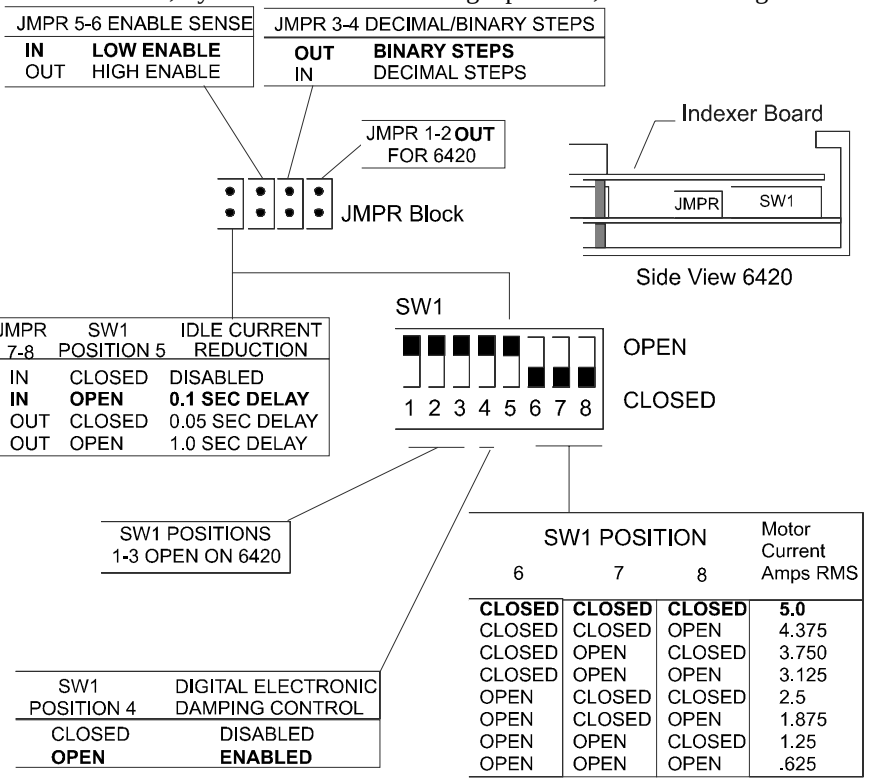
2.5.1. DRIVE

The drive has an eight-position DIPswitch (S1) and a group of four jumpers (J6) controlling drive current, digital electronic damping, idle current reduction and binary or decimal step size. The DIPswitch is easily accessible without removing the Indexer card. The default factory set jumpers are suitable for most applications but can be modified, if necessary. The jumpers (J6) may be removed using needle-nose pliers. To reinstall the jumper, loosen the screws on the indexer board. If the indexer board must be removed, it must be re-aligned properly before tightening the screws.

When installing the indexer board, ensure the 20-pin connector is aligned properly. Misalignment seriously damges the drive.

2.5.2. INDEXER

The Indexer has thirteen plugs on jumpers (E1 through E13) controlling RS Communications, Synchronous or Alternating Operation, and I/O Configuration.



2.5.3. DRIVE BOARD SETTINGS

Switch S1 & Jumper J6

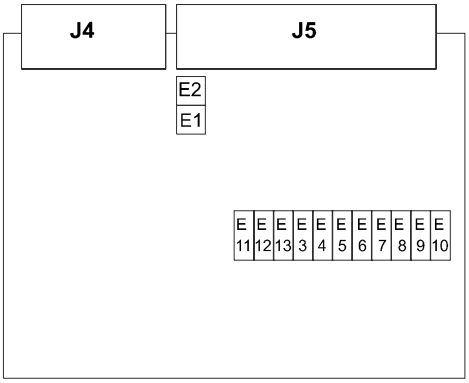
Drive switch settings

Default settings are in bold.

2.5.4. INDEXER BOARD SETTINGS

Indexer
The Indexer has thirteen plug on jumpers (E1 through E13) controlling RS Communications, Synchronous or Alternating Operation, and I/O Configuration.

Jumper Location



2.5.4.1. JUMPER SETTINGS

E1 and E2

Configuration	E1	E2
	IN	OUT

Do NOT modify these jumpers.

E11

E11	RS Communication Configuration
IN	RS-485 Communications
OUT	RS-232/RS-422 Communications

The factory default is Jumper OUT enabling RS-232 and RS-422 communications.

E12 and E13

E12	E13	Synchronous or Alternating Operation Configuration
IN	OUT	Alternating Operation
OUT	IN	Synchronous Operation

Factory default setting is E12 OUT, E13 IN.

E3 to E10

Jumpers E3 to E10 control discrete I/O bit directions.

E3 to E10	I/O Configuration
IN	Output
OUT	Input

Factory default settings are all jumpers OUT configuring all lines as INPUTS.

3. POWERING UP THE 6420

This chapter explains how to power up the 6420 after installation.

3.1. TESTING THE INSTALLATION

Perform the following test procedure to verify the 6420 is installed properly and was not damaged internally during shipment. The installation and power-up procedure requires a motor and computer or terminal to test the basic functionality of the 6420.

After performing the installation, test your installation using the following steps.

Perform an initial power-up with the motor shaft disconnected from the load. Improper wiring or undiscovered shipping damage can result in undesired motor motion. Be prepared to remove power if excessive motion occurs.

Before beginning the connections test, please check:

- All wiring and mounting to verify correct installation.
- Specifications to ensure applied voltages do not exceed the voltages specified.

1. Connect only J2 (unregulated 24 VDC to 75 VDC input) to the 6420 and apply power.
2. Verify +5.7 VDC at the 6420 J5-13 to J5-5 (voltage should be 5.2 V to 5.9 V). If it is not, refer to Troubleshooting.
3. Switch power OFF.
4. Connect the J3 motor connector.
5. Switch power ON again.
6. Verify the motor has holding torque by attempting to rotate the motor shaft. The energized shaft is either immovable or very resistant to rotation when the drive is enabled.
7. Connect the J4 RS-232 connector.
8. Cycle power to the controller. If using a PC, use the 6420 Dialogue disk to set up your PC as a dumb terminal.

9. Type ESC and a single space character. The controller should respond with a pre-defined sign-on message:
   5134 PACIFIC SCIENTIFIC ©1994
   v1.10
10. Enable the 6420 by connecting J5-7 (Enable1) to J5-5 (GNDA).
11. From the terminal or computer type, **R100<enter>**. This should move the motor at a velocity of 100 steps per second clockwise.
12. Type **R-100<enter>**. This should change the direction of the motor rotation.
13. Type **S <enter>**. The motor should stop rotating.

If the controller passes all of the above, start exercising the unit on your own. If the 6420 does not pass all of the above steps, refer to Troubleshooting.

4. MAINTAINING\TROUBLESHOOTING

This section covers maintenance and troubleshooting of the 6420.

4.1. MAINTAINING THE 6420

The 6420 module is designed for minimum maintenance. Remove superficial dust and dirt from the module using clean, dry, low-pressure air.

4.2. TROUBLESHOOTING THE 6420

Use the following table to diagnose and correct most problems. If you are unable to achieve satisfactory operation, contact your local Danaher Motion distributor or applications engineering department.

Symptom	Corrective Action
No RS-232 Communication	Verify that the 6420 E11 jumper is OUT, placing the 6420 into single-unit, RS-232/RS-422 mode. Verify that the transmit of the host terminal is wired to the 6420 receive and vice-versa. Normally DTE (Data Terminal Equipment) devices transmit data on pin 2 and receive data on pin 3. Verify the serial port settings to be 9600, N, 1. Verify your host is working properly. Disconnect the D-9 connector from the 6420 unit. Wire pins 2 and 3 of this connector together. Try typing characters on the keyboard. Each character should be echoed back to the screen. If not, check your cabling and connectors. Refer to your host reference guide.

Symptom	Corrective Action
Motor does not spin	Verify that the motor is properly connected with no open wires or shorts. With the 6420 energized, try twisting the motor shaft. If you are able to easily spin the shaft, especially at the higher motor current levels, chances are the motor is disabled. The drive board J6 pins 5-6 (Enable sense) should be IN and J5 pin 7 (ENABLE) should be wired to a ground pin on the J5 connector. Verify that some motor problem has not created a Fault condition. A Fault has occured if J5 pin 12 is low or the Read HW status command returns with Bit 7 high. If so, correct the condition that created the fault. If you issued the **T** command with Indexer jumpers E12 and E13 set for alternating operation, you may have disabled step pulses to the motor. Double-check your jumper configuration and usage of the **T** command.
Motor spins, but tends to stall	Experiment with the **M** command by issuing **M 255 255** which results in the slowest possible acceleration and deceleration. Possibly, your motor cannot generate enough torque for your application. Try resizing.
Unit does not respond to commands	If the power supply is not adequate for the load, a momentary drop in power may reset the unit and require that the sign-on procedure be repeated. It is possible a maximum velocity value, well above the specified range may have been executed. Try cycling power and resetting any erroneous parameters before issuing another motion command. If the error occurs in an AUTOSTART program, try ESCaping as soon as possible before the maximum velocity is attained. Cycle power.

If you cannot correct the drive problem or if it is defective, return it to Danaher Motion for repair or replacement. Call Danaher Motion at (815) 226-2222 from 8 am to 6 pm Central Standard Time to get a Returned Materials Authorization Number (RMA#). Pack the drive in its original shipping carton. Shipment of your drive or motor to Danaher Motion constitutes authorization to repair the unit. **Specify the means of shipping desired at the time you request a RMA#.**

Do not attempt to return the 6420 or any other equipment without a valid RMA#. Returns received without a valid RMA# will not be accepted and will be returned to the sender.

5. PROGRAMMING AND INSTRUCTION SET

The 6420 can operate in Immediate or Execution Mode. Immediate Mode is an interactive, command-line mode where commands are entered and immediately executed. Immediate Mode is used during program development or when controlling the unit with a host computer. Execution Mode is used when the 6420 is executing a program out of its non-volatile memory, usually when used as a standalone Indexer. During power-up, if the AUTOSTART program is found at location 1600 in non-volatile memory, execution begins at 1600. If the REMOTE START line is activated (LOW) in Immediate Mode, the unit starts executing the program at location 0 in memory.

5.1. IMMEDIATE MODE

After power-up, providing that neither REMOTE START nor the AUTOSTART are active, the 6420 is in Immediate Mode. If the 6420 is configured for RS-232 or RS-422 serial communications, it waits for one **ESC** and space character, then responds with the sign-on message and copyright notice. Commands are sent via the serial link and are terminated with a carriage return **<CR>**. The 6420 responds with any requested data followed by a **<CR><LF>**. Only one command is sent at a time. Motion commands immediately echo a **<CR><LF>** and carry out the motion in the background. If a second motion command is sent to the 6420 while another is in progress, the **<CR><LF>** response is delayed until the original command is complete.

Programs can be entered into non-volatile memory while in Immediate Mode. Use either a terminal emulator program or the 6420 Dialogue to facilitate program development. The **E *address*** command allows you to edit a program starting at the location specified by address. The starting address is echoed, indicating where the command goes in memory. You can continue to enter successive commands line by line. If an entry error occurs before **<CR>**, the backspace or delete key can be used to correct the error. If the error is noticed sometime later, leave the edit mode by entering **E <CR>** and start editing at the line where the error was made by entering E error_address followed by **<CR>** . If you want to selectively change only the line where the error occurred, enter the new command followed by **<CR>** as you normally would do, but leave the edit mode by pressing **ESC** instead of **E <CR>**. If you inadvertently enter the **E <CR>** combination, the next command in the program is over-written with an invisible program termination code and you will have to go back and selectively replace this line.

If you want to continue editing the program from this point on, continue to do so and conclude editing with **E <CR>**. Test the program by using the **G *address*** command to execute the code. The program continues to execute until it completes or you press **ESC**.

If the 6420 is configured for multi-unit RS-485 communication, no sign-on message appears. Commands are sent to individual units based on a pre-assigned node address (assigned in single-unit mode) followed by the command, terminated by a line feed **<LF>** character. Once a unit recognizes its single-letter node address, that address character and commands entered up to the **<LF>** are echoed back to the user.

5.2. EXECUTION MODE

Once the program starts, it continues to execute until it is complete, aborted with the **S0** command embedded in the program, aborted by **ESC**, **S** or the REMOTE STOP line.

5.3. THE AUTOSTART PROGRAM

During power-up, if a program is found at location 1600 in non-volatile memory, that program (the AUTOSTART program) is executed. This program is aborted by pressing either **ESC** or **S**. Both keys forcd the unit back to the power-up state and waits for the **ESC** and space character sign-on sequence.

5.4. INSTRUCTION OVERVIEW

The 6420 offers a variety of instructions for motion and program control in addition to several utility instructions. All instructions can be entered on a command line basis in immediate mode with many, but not all, available for use within programs executed from on-board non-volatile memory. The instruction categories include:

Motion Control
Program Control
Parameter Initialization
Initialization and Utility Commands

5.4.1. MOTION CONTROL

Incremental and absolute indexes run at constant velocity and home to a known position. All the motion commands immediately echo **<CR><LF>** and carry out their motion in the background. The incremental and absolute indexes execute a trapezoidal velocity profile, accelerating from the initial velocity, accelerating to the final velocity, decelerating back to the initial velocity ending at zero velocity.

5.4.2. PROGRAM CONTROL

Such as **P** for program mode, **G** for executing programs and jumping within a program, **J** and **B** for executing interative loops, **U** for conditional branches based in the input ports.

5.4.3. PARAMETER INITIALIZATION

Such as **F** to set the initial velocity, **V** to set the final velocity, **M** to set the acceleration and deceleration profiles, **O** to setup for a position trip point.

5.4.4. INITIALIZATION AND UTILITY COMMANDS

Such as **A** to initialize memory, **P** to store current parameter values, **E** to edit a program.

5.5. MEMORY MAP

5.5.1. USER PROGRAMS

Approximately 1792 bytes are available for user programs. The maximum size of a program in terms of number of command lines is dependent on the actual commands used since each command is composed of 1 to 5 bytes. In general, programs can be entered into the entire 1792 byte range of user program memory. However, certain commands, when utilized, require specific areas of memory to be reserved for their use.

5.5.2. FAST RAM

There is a 64 byte segment, extending between locations 128 to 191, marked as Fast RAM. This area is fast static RAM inside the microprocessor used when a specific command (the Trip and Output) requires it and when higher response or looping speed is necessary in an application. As the name implies, this area is NOT saved when the unit is powered-down. To save the program(s) in this area to non-volatile memory, issue the **P** command. Upon power-up, the contents are automatically restored.

5.5.3. MEMORY MAP DETAILS

Address	Description
0-255	User Programs. Location 0 is the starting location when the REMOTE START input is activiated. Locations 128-192 are FAST RAM locations and are not saved when the unit is powered down until **P** (Store parameters) is issued.
256-511	User programs and G 2048 Indexed jump
512-767	User Programs
768-1023	User Programs
1024-1279	User Programs
1280-1535	User Programs
1536-1791	User Programs. Location 1600 is starting address for AUTOSTART.
1792-1893	RESERVED: Variable resolution fraction look-up table.
1894-2047	RESERVED: Motion parameter storage, may be read by the Read Memory command >.

6. 6420 DIALOGUE

6420 Dialogue is a menu-driven software package containing several software utilities. These utilities are designed to run on an IBM compatible PC and interface to Danaher Motion's Pacific Scientific motion control hardware via an RS-232 serial link. The tools available are:

1) Terminal Emulator
   The Terminal Emulator allows the PC to be used as a dumb terminal. In this mode, the PC is acting as a terminal and allows the generation and editing of programs directly on the hardware (on-line).
2) Upload Utility
   Upload allows files to be read out of the controller's memory into a file on a PC's floppy or hard disk drive.
3) Download Utility
   Download allows files to be taken from the PC's disk drive and transferred into the position controller's memory.
4) Syntax Checker
   The Syntax Checker checks programs for errors before transferring them to the controller.
5) Editor
   The Editor creats and edits programs. Programs can be created and edited without the controller being connected to the PC (off-line). The resulting program can be stored on the PC's disk drive for downloading to the controller at a convenient time. Programs can be read from the hardware using the Upload Utility and be modified with the Editor.
6) Init Serial Port
   Init Serial Port allows you to select a COM Port for serial communication.

6420 Dialogue is contained on a single 3-1/2 inch diskette.

6.1. GETTING STARTED

6420 Dialogue is executed directly from the 6420 Dialogue disk supplied or can be installed on the PC's hard disk. If 6420 Dialogue is executed directly off the supplied disk, make a backup copy and store in a safe place.

6.1.1. USING THE 6420 DIALOGUE FLOPPY DISK

Follow the steps below to use the 6420 Dialogue floppy disk:

1. Boot up the PC
2. Set the PC to directory **A:**
3. Insert the 6420 Dialogue floppy disk into drive A
4. Type **6420 <enter>**

6420 Dialogue should be running and you can select the tool desired.

6.1.2. INSTALLING 6420 DIALOGUE ON A HARD DRIVE

The 6420 Dialogue disk is supplied with an installation program. This program creates a sub-directory named **\6420** on the hard drive and copy the 6420 Dialogue files from the floppy disk into the sub-directory. The installation program assumes that the hard drive is designated **C:**. To install 6420 Dialogue on the PC's hard drive, follow the steps below:

1. Boot up the PC.
2. Insert 6420 Dialogue disk in drive A.
3. Type **A: INSTALL <Enter>**.

6420 Dialogue should be installed on the hard disk. To run 6420 Dialogue, go to the 6420 directory, and type **6420 < Enter >**.

6.1.3. SERIAL PORT CONNECTIONS

6420 Dialogue can be used to generate programs off-line. However, programs have to be downloaded or uploaded between the PC and the motion control hardware at some point. The RS-232 serial link is used to communicate between the PC and the hardware.

Many PCs have two serial communication ports, COM1 and COM2. One of these must be wired to the motion control hardware. Refer to the PC's *Hardware Reference Manual* and the *Instruction Manual* provided with the motion control hardware for wiring information. Use the **Init Serial Port** tool on the **Main Menu** to select the correct COM port and to set the serial link parameters.

Default serial link parameters for the 6420 are displayed.

6.1.4. KEYBOARD COMMANDS

The choices from a Main Menu are highlighted by using the **<Up >** or **<Down>** arrow keys. Selection of the highlighted item is made by entering the choice with **<Enter>**. This selection brings up a prompt, a list and/or a sub-menu. Choices are made from a sub-menu or list using the **<Up>** key to move up, or the **<Down >** key to move down, then entering a choice with the **<Enter>** key.

Pressing **<Esc>** aborts the current operation and either returns to the previous menu or exits the program. **<Esc>** also exits from the Editor. To exit from a Terminal Emulator session, press **<Ctrl><E>**.

The keyboard command definitions are displayed in appropriate places on the screen to assist you.

6.1.5. TERMINAL EMULATOR

The PC can be used as a dumb terminal to communicate with the selected controller. The PC's serial port is initialized when 6420 Dialogue is started. The parameters can be changed with the **Init Serial Port** utility.

To exit the Terminal Emulator at any time, press **<Ctrl><E>**. This returns to the Main Menu.

6.1.6. UPLOAD UTILITY

After selecting this utility, you are prompted for a filename for the uploaded file. By default, the uploaded file is created in the current directory. If you select an existing filename, that file is overwritten. It is good practice to use a different extension or filename for the uploaded file. In particular, the *filename.ext* of the downloaded source file should not have the same *filename.ext* as the uploaded file or the source file contents are replaced with the uploaded file. When choosing extensions for filenames, avoid using .LST. The 6420 Dialogue program uses the .LST extension for the listing files created by the Syntax Checker.

The Upload Utility will not function properly if voids (empty addresses) exist between sections of code in the memory. Contact the factory for additional information.

After a file has been successfully uploaded, **Upload completed** is displayed. If the *<Path>\filename.ext* is unacceptable, **Couldn't open file** is displayed. When uploading a file, labels are generated for any branch to address command.

For a downloaded program, the symbolic labels and references are stripped out and replaced with numeric addresses. At uploading, these are replaced with numeric sequential labels. It is good practice to use a different extension or filename for uploaded files.

6.1.7. DOWNLOAD UTILITY

After selecting this utility, you are prompted for a *<Path>\filename.ext* that can be typed in or selected from the current directory list. If the download is successful, **Download completed** is displayed.

6.1.8. SYNTAX CHECKER

Using the Syntax Checker, programs are checked for syntax validity prior to downloading or running. Syntax Checker creates a listing file with the extension .LST for the file sent to Syntax Checker or sent to the Download Utility (automatically calls Syntax Checker).

If the syntax check is successful, **No syntax error(s) detected** is displayed and the listing file with the message **NO ERRORS FOUND** is sent to the display. If errors are found, **Syntax error(s) detected** is displayed, and the listing file containing the program code and syntax error messages, is displayed. Use the Editor to review the syntax errors listed in the .LST file.

To reposition the syntax error dialog box, press **F2** and use the arrow keys to move to the desired position. Once the dialog box is positioned, press **F2** or **<Enter>** to see errors. To edit a line, return to the editor.

6.1.9. EDITOR

After selecting this utility, you are prompted for a *<Path>\filename.ext* that can be typed in or selected from the current directory's file listing. If the filename does not exist, you are prompted with **Create?** The response is either **Y** (yes) or **N** (no). If answering **N**o, the system responds with c**an't load file** (does not exist), after which, **<Enter>** returns to the Main Menu level. If answering **Y**es, you enter the Editor.

When exiting the Editor (pressing **<Esc>**), you are prompted with **Save file (y/n) ?** Answering **N <Enter >** , returns to the Main Menu, without saving the file and all edits are lost. Answering **Y <Enter>** brings up a prompt for the filename. The current file being edited is saved under the existing filename by pressing **<Enter>**. The name can be changed by typing over the current filename, followed **<Enter>**.

While using the Editor, many operations (justify, cut, paste, etc.) are available. These operations are assigned to various keys:

ESC	Exit the Editor.
INSERT	Toggles insert and typeover mode, (**default: typeover mode**).
F7	Attach file to the end of current file (**default: off**).
F8	Toggles whether hard and soft carriage returns are symbolically displayed in the edit window, (**default: not displayed**)
F9	Toggles editor display from 128 ASCII characters to 256 IBM characters, (**default: ASCII characters**).
F10	Reformats a paragraph.
UP ARROW	Moves cursor up a line.
DOWN ARROW	Moves cursor down a line.
LEFT ARROW	Moves cursor left a space.
RIGHT ARROW	Moves cursor right a space.
CTRL-A	Move cursor one word to the left.

CTRL-F	Move cursor one word to the right.
CTRL-Y	Delete line cursor is on.
CTRL-Z	Scroll up a line.
CTRL-W	Scroll down a line.
HOME	Move cursor to beginning of line.
END	Move cursor to the end of line.
PGUP	Previous Page.
PGDN	Move to top of screen.
CTRL-END	Move to bottom of screen.
CTRL-PGUP	Move to beginning of file.
CTRL-PGDN	Move to end of file.
TAB	Tab.
ALT-M	Begin marking a block of text, use cursor arrows to mark rest of block.
ALT-C	Copy marked block to scrap.
ALT-X	Cut marked block to scrap.
ALT-P	Paste scrap at cursor position.
ALT-S	Search for pattern (target); starts search, cancels search.

6.1.10. INIT SERIAL PORT

This utility initializes or changes the serial port parameters. If the parameters do not need to be changed, press **<Esc>**. Pressing **<Esc>** at any point in the Init Serial Port menu exits without saving changes to the parameters.

The parameters are selected with the up or down arrow keys. As each parameter is highlighted, its sub-menu displays the list of each parameter's values. Move through the choices with the **<Up>** and **<Down>** keys. A parameter and its value are entered with a **<Enter>**.

To exit the Init Serial Port menu after making changes to any parameters, press **<Enter>** after the last parameter in the menu. Any changes made to the parameters are saved to a disk file in the current directory after exiting the Init Serial Port menu, and are used as the default settings upon the next invocation of 6420 Dialogue. These default settings are stored in the binary data file, **PORT.CFG**.

6.2. INDEXER LANGUAGE

Danaher Motion's Indexer Language is a modified form of the program language of Danaher Motion's Pacific Scientific 5240 Stepping Motor Indexer/Drive. The language for the 6420 is modified so symbolic labels can be used as the operand for branching to address commands (**J**, JUMP). Syntax checking is done on the Indexer Language, and labels are translated to their target address by the Syntax Checker before a program is downloaded. When a program is uploaded, labels are generated for the operands of branch to address commands.

6.2.1. SYMBOLIC LABELS IN PROGRAMMING

A line of program code has the format:

<LABEL> ***COMMAND*** ***OPERAND1*** ***OPERAND2***

where ***<LABEL>*** is optional
OPERAND2 exists only for some commands.

One or more blanks must be used between a label and a command, or between operands, but blanks are not necessary between the ***COMMAND*** and ***OPERAND1***. Tabs may be used in place of blanks. The branch to address commands, **G** (GOTO), "**J** (JUMP) and **U** (LOOP), may have a label or an address for ***OPERAND1***. The label reference in ***OPERAND1*** must have a matching label somewhere in the program or a syntax error is generated. Duplicate label names are not allowed and generate a syntax error.

The format for a label is:

$ < *STRING* >

where there are no blanks between the dollar sign (**$**) and the string.

The string is limited to eight characters composed of any sequence of digits and letters (including the underscore). Any variation from this format generates a syntax error. The maximum number of labels allowed for any program is 200.

Labels are only used in Editor Mode.

For example, here is an example program that uses labels:

```
$ begin k
      j $ begin 1
$ loop +1000
      u $ loop 5
      g $ end
$ end s
```

The labels in this program are begin, loop, and end.

6.2.2. SYNTAX CHECKER

The Syntax Checker checks for valid syntax for each line of code. If no syntax errors are found, the Syntax Checker takes out all symbolic labels and label references, and inserts the target address for each label reference (a label reference is a label used as the operand for a branch to an address command). If an error is found, the program and error messages are put into a displayed listing file. The possible error messages are:

1. invalid input; label or program command expected
2. invalid label; expecting alphanumeric after delimiter
3. invalid label or, expecting valid command after label
4. invalid operand; digit '1' expected
5. invalid operand; expecting digit
6. EOL encountered; expecting operand
7. invalid input;no operand required
8. invalid input; expecting EOL character
9. invalid input; expecting valid number or label
10. illegal for this command to have a label reference
11. invalid operand; +,- character not allowed after +,- command
12. invalid number; input number is out of range
13. invalid operand; reference to nonexistent label
14. invalid label; duplicate label name exists

The end of line character (EOL), defined as the linefeed character, is expected at the end of each line of code.

6.2.3. ADDRESS TRANSLATION OF LABELS

Before a 6420 program is downloaded, it is automatically syntax checked. If there are no syntax errors, the Syntax Checker takes out all labels from the program and translates the label references to address. The program thus contains only commands and numeric operands, and is downloaded to the controller.

6.2.4. LABEL GENERATION FOR ADDRESSES

When a 6420 program is uploaded, labels are generated for the operands of branch to address commands. The labels are inserted in the appropriate places in the program. The labels generated have the form, **$L*xxx***, where the labels are sequentially generated starting with **$L000**.

If a 6420 program is written off-line on the PC with labels and downloaded, when the program is uploaded, the labels take the form described above. The labels used in the program prior to downloading exist only in the original file on the PC.

To avoid confusion when developing 6420 programs, follow the labeling scheme used by the Upload Utility. That is, when writing a 6420 program on the PC, use labels of the form **$L*xxx*** starting with **$L000** and progress sequentially through the program. By following this practice, a program will not change labels when downloaded and then uploaded.

7. PROGRAMMING INSTRUCTIONS

This section contains detailed descriptions of the 6420 commands. The command, mode of operation, and where it can be used is listed at the top of the page. Commands are then described using the following format:

Purpose - purpose of the instruction
Syntax - exact format of the command
Programming guidelines – guidelines for using the command
Example - example of the instruction in a program segment

^ (Set Jog Speed)

^ *speed*

Immediate, Execution

Purpose Sets jog speed. This value is multiplied by 30 to determine speed in pulses/second. Acceleration is ramped. Deceleration is normally not ramped except in the case of activating both JOG inputs and releasing one. Jog inputs are active in idle mode.

Syntax ^ ***speed***

Arguments $0 \leq speed \leq 255$

@ (Absolute Move)

@ position

Immediate, Execution

Purpose

Indexes the motor to an absolute position given by the internal position counter.

In Fixed Resolution mode, the position specifies ±8,388,607 pulses. If

position = 200
StepSize is Full steps

the shaft spins 1 revolution.

If

position = 1600
StepSize is 1/8 step (1600 pulses/rev)

the shaft also spins 1 revolution.

In Variable Resolution mode, the position specifies ± 8,388,607.99 Full steps with 0.01 step size resolution (20,000 pulses/rev). If:

position = 200.00

the shaft spins 1 revolution.

Syntax

@ position

Arguments

- 8,388,607 ≤ position ≤ + 8,388,607 (Fixed Resolution)
- 8,388,607.99 ≤ position ≤ + 8,388,607.99 (Variable Resolution)

Programming Guidelines

Program Line	Explanation
M 10 10	
F 300	
V 1000	
Z	zero the position counter
@ 2000	index to position 2000
W 0	wait till index done
W 150	wait 1.5 seconds
Y 1	activate Port 1 (output LOW)
@ 0	index back to initial position
W 150	wait 1.5 seconds
Y 0	de-activate Port 1 (output HIGH)

Related Commands

M — set acceleration/deceleration profile
F — set initial velocity
V — set final velocity
I — set Resolution Mode
\ — set StepSize
Z — Zero Position Counter

+ (Positive Incremental Move)

+ steps

Immediate, Execution

Purpose

Moves the motor a total of steps in the CW direction with a trapezoidal velocity profile shown below.

In Fixed Resolution mode, the steps specifies ± 8,388,607 pulses. If:

steps = 200
StepSize is Full steps
the shaft spins 1 revolution.

If

steps = 1600
StepSize is 1/8 step (1600 pulses/rev)
the shaft also spins 1 revolution.

In Variable Resolution Mode, the steps specifies ± 8,388,607.99 Full steps with 0.01 step size resolution (20,000 pulses/rev). If:

steps = 200.00
the shaft spins 1 revolution.

Syntax

+ steps

Arguments

0 ≤ steps ≤ + 8,388,607 (Fixed Resolution)
0.00 ≤ steps ≤ + 8,388,607.99 (Variable Resolution)

Programming Guidelines

Program Line	Explanation
M 10 10	set accel/decel factors
F 300	set initial velocity
V 1000	set final velocity
+ 1000.52	index 1000.52 steps

Related Commands

M — set accel/decel
F — set initial velocity
V — set final velocity
I — set resolution mode
\ — set StepSize

- (Negative Incremental Move)

- steps

Immediate, Execution

Purpose

Moves the motor a total of steps in the CCW direction with a trapezoidal velocity profile shown below.

In Fixed Resolution mode, the steps specifies ± 8,388,607 pulses. If:

steps = 200
StepSize is Full steps
the shaft spins 1 revolution.

If:

steps = 1600
StepSize is 1/8 step (1600 pulses/rev)
the shaft also spins 1 revolution.

In Variable Resolution Mode, the steps specifies ± 8,388,607.99 Full steps with 0.01 step size resolution (20,000 pulses/rev). If:

steps = 200.00
the shaft spins 1 revolution.

Syntax

- steps

Arguments

0 ≤ steps ≤ + 8,388,607 (Fixed Resolution)
0.00 ≤ steps ≤ + 8,388,607.99 (Variable Resolution)

Programming Guidelines

Program Line	Explanation
M 10 10	set accel/decel factors
F 300	set initial velocity
V 1000	set final velocity
- 1000	index 1000 steps at current resolution

Related Commands

M — set accel/decel
F — set initial velocity
V — set final velocity
I — set resolution mode
\ — set StepSize

\ (StepSize, VelScale)

\ *arg*

Immediate, Execution

Purpose

In Fixed Resolution mode, sets the StepSize. In Variable Resolution mode, sets VelScale to scale actual shaft speed.

Syntax

\ ***arg***

The resolution settings also depend on the drive settings. For this instruction, select either binary or decimal step sizes. The factory default is binary step sizes.

Arguments

Fixed Binary	Fixed Decimal	VR Speed
0 = Full	Not allowed	Full speed
1 = 1/2	Full	1/2
2 = 1/4	1/2	1/4
3 = 1/8	1/5	1/8
4 = 1/16	1/10	1/16
5 = 1/32	1/25	1/32
6 = 1/64	1/50	1/64
7 = 1/128	1/125	1/128
8 = 1/256	1/250	1/256

Programming Guidelines

In the following program, assume the unit is set for Fixed Resolution Mode.

Program Line		Explanation
E0		
0	\0	Full steps (200 steps/rev)
2	+ 1000	spin CW 5 revolutions
7	W 0	
10	W 100	
13	\2	Quarter steps (800 steps/rev)
15	- 1200	spin CCW 1.5 revolutions
20	W 0	
23	W 50	

In Variable Resolution Mode:

Program Line		Explanation
0	\0	Full speed
2	+ 1000	spin CW 5 revolutions
7	W 0	
10	W 100	
13	\2	1/4 speed
15	- 1200	spin CCW 6 revolutions
20	W 0	
23	W 50	

ESC (Abort)

ESC

Immediate

Purpose

Terminates any active operation and returns Indexer to the immediate or idle mode. If motor is in motion, it is immediately stopped without ramping deceleration. Output ports are not affected. In RS-485 multi-unit mode, motion on all axes stops.

^C (Software Reset)

^C

Immediate

Purpose Stops all axes, loads default parameter values, zeros origin, executes any user program (AUTOPROGRAM) at location 1600. Indexer waits for the spacebar sign-on or external REMOTE START or JOG+ or JOG- inputs.

> (Read Memory)

> addr size

Immediate

Purpose Displays a specified block of non-volatile memory starting at *addr*, returning a total of *size* bytes. *addr* must be in the range of 0 to 2047 and *size* 0 - 255. Displayed values are in decimal format.

Syntax > ***addr size***

Arguments $0 \leq addr \leq 2047$ and $0 \leq size \leq 255$

< (Write Memory)

< addr data

Immediate

Purpose Writes a data byte to an address specified by *addr* in non-volatile memory. *addr* must be in range of 0 to 2047 and *data* must be in range of 0 to 255.

Syntax ***< addr data***

Arguments 0 ≤ addr ≤ 2047 and 0 ≤ size ≤ 255

] (Read Moving Status)

]

Immediate

Purpose Returns an integer number representing the current move status. Bit weights 1 => Indexing, 2 => Constant Speed, 128 => Drive Fault.

Syntax]

: (Selective Termination)

: axis

Immediate

Purpose Aborts operations on a particular axis when configured for RS-485 communications mode.

Syntax ***: axis***

Arguments Where *axis* is the single-letter axis designation.

‘ (Trip and Output)

‘*nextpos port*

Execution

Purpose

Designed to be used within a Trip Point Service Routine (TPSR) and provides the capability of setting or clearing user I/O lines as a function of current position. Set up a Trip Point (O command) in the normal fashion, but with an entry address in fast RAM locations 128 to 191, such that the entire TPSR resides within the fast RAM range. When the Trip and Output instruction is executed, the port parameter is sent out to the bi-directional ports. *nextpos* sets the next trip point position. **Q** always shows the next trip point. Trip and Output instructions must be embedded within the TPSR in contiguous locations. At end of sequence, a new Trip Point can be specified.

Syntax

‘ nextpos port

Programming Guidelines

The following example activates ports P1, P2, P3, P4 in sequence as successive positions are traversed. **O** sets the initial trip point to position 1000 and vector address to 128. When this position is encountered, execution vectors to location 128. The Trip and Output instruction at location 128 writes a 1 to the bi-directional ports and sets the next trip point to position 5000 and the vector address 133. Subsequent execution continues in a similar manner.

Only the* E *command at the conclusion of editing is necessary to end the trip point service routine.

Program Line		Explanation
E0		
0	Z	zero position
1	O 1000 128	trip at pos 1000
6	+ 50000	index
11	W 0	till done
14	W 100	wait 1 sec
17	G 0	loop

```
E128
128  ‘ 5000 1
133  ‘ 10000 2
138  ‘ 15000 4
143  ‘ 20000 8
148  ‘ 25000 4
153  ‘ 30000 2
158  ‘ 35000 1
E
```

= (Limit Switch Polarity)

= polarity

Immediate

Purpose Sets the limit switch polarity. The default limit input upon power up is active LOW.

Syntax ***= polarity***

Arguments 1 = Active Low
0 = Active High

A (Clear and Restore)

A *opcode*

Immediate

Purpose

This command initializes a portion of non-volatile memory. Non-volatile memory is segmented into 8 pages. The specified *opcode* determines precisely the page to be erased, reloaded or initialized.

Syntax

A *opcode*

Arguments

A0	Reloads the last saved NVRAM parameters.
A1 to A7	Erase the corresponding page in NVRAM.
A8	Completely initializes NVRAM to default values.
A9	Initializes variable resolution fraction look-up table to default values. List of 100 eight-bit values starting at location 1792 in NVRAM.

Programming Guidelines

Memory Map Details:

Erase Cmmd	Address	Notes
A1	0-255	User programs. Location 0 for REMOTE START input. Locations 128-192 are Fast RAM locations.
A2	256-511	User programs and G 2048 Indexed jump.
A3	512-767	User programs.
A4	768-1023	User programs.
A5	1024-1279	User programs.
A6	1280-1535	User programs.
A7	1536-1791	User programs. Location 1600 for AUTOSTART.
XX	1792-1893	RESERVED: Variable resolution fraction look-up-table.
XX	1894-2047	RESERVED: Motion parameter storage, read by the Read Memory command.

C (Read Position Counter)

C *arg*

Immediate

Purpose

Displays current position counter value. In Fixed Resolution Mode, the value is an integer. In Variable Resolution Mode, the value is a mixed integer/fractional value in range of ± 8,388,607.99 to steps. Specifying *arg* = 1, enables continuous echoing of position via the serial interface only in single-unit mode.

Syntax

C *arg*

Arguments

arg is 0, 1

Programming Guidelines

Normally used when the 6420 is controlled by a host computer or with a terminal emulator.

Press **Z <Enter>** followed by **C <Enter>**. The value 0 should be displayed. Index incrementally by typing **+200 <Enter>**. Press **C <Enter>** again and 200 should now be displayed.

E (Edit Program)

E *addr*

Immediate

Purpose

Allows entry of user programs for subsequent execution by the **G** (GO) command or execution of a program at location 0 with activation of the Remote Start input or AUTOSTART at power-up. *addr* specifies the address at which to edit a new or existing program.

Syntax

E *addr*

Programming Guidelines

Example

ProgramLine	**Explanantion**
E 100	Edit a program starting at location 100
M 10 10	
F 400	
V 1200	
+ 1000	
E	

Edit Program mode is entered by the **E 100**. Various commands are entered and terminated by **<Enter>**. When completed, the last **E** inserts a terminator byte at the end of the program, over-writing any pre-existing data. Pressing **ESC** instead of the last **E** prevents over-writing the next command. This is useful for patching in corrections to an existing program when using a terminal emulator.

Program execution can be interrupted by Remote Stop, **ESC**, or **S**. After interruption of an AUTOSTART program, the sign-on procedure must be carried out.

F (Initial Velocity)

F *vel*

Immediate, Execution

Purpose

Sets the initial velocity to vel pulses/second. In Fixed Resolution Mode, the actual speed in steps-per-second is determined by the current step size.

Syntax

F *vel*

Arguments

$0 \leq vel \leq 19{,}000$

Programming Guidelines

Program Line	Explanation
F 300	set the initial velocity
V 3000	

Example

If vel = 1000 and the step resolution is set for Full Steps (200 pulses/rev), the shaft spins at 1,000 full steps/sec or 300 rpm. If vel = 1,000 and the step resolution is set for 1/8 Steps (1,600 pulses/rev), the shaft spins at 125 full steps/sec (37.5 rpm)

In Variable Resolution Mode, the speed is determined by the VelScale factor.

If VelScale is set by issuing \ 0 (the nominal value), and vel = 1000, the shaft spins at 1,000 full steps/sec (300 rpm). If VelScale is set by issuing \ 2, and vel = 1000 the shaft spins at 250 full steps/sec (300 rpm * 0.25 = 75 rpm).

Related Commands

V — Set final velocity

G (Go)

G *addr* [*trace*]

Immediate, Execution

Purpose

Executes a user program at a specified *addr*. The optional *trace* argument allows execution tracing. *addr* specifies the starting address of a program in the range of 0 to 1791. A special case is where addr = 2048, which executes an indexed jump based on the lower 4 I/O port bits to 16 locations within address locations 256 to 496.

Syntax

G *addr* [*trace*]

Arguments

0 ≤ addr ≤ 1791, or 2048 for indexed jump on inputs
trace = 0 or 1

Programming Guidelines

Program Line		Explanation
E0		
0	M 10 10	
3	F 300	
6	G 2048	execute Indexed Jump

Jump Table The following jump table is used for an indexed jump, which might be used for a rotary switch used to select 1 of 16 different operations.

Jump Loc	P4	P3	P2	P1	Jump Loc	P4	P3	P2	P1
256	1	1	1	1	384	0	1	1	1
272	1	1	1	0	400	0	1	1	0
288	1	1	0	1	416	0	1	0	1
304	1	1	0	0	432	0	1	0	0
320	1	0	1	1	448	0	0	1	1
336	1	0	1	0	464	0	0	1	0
352	1	0	0	1	480	0	0	0	1
368	1	0	0	0	496	0	0	0	0

H (Home)

H *speed dir*

Immediate, Execution

Purpose

Home initiates a search for home position. Home is executed with *dir* set for motion moving the assembly toward the home switch at speed steps/second. When the home position is reached and the home input switch is activated, the motor reverses direction and moves at a speed equal to the initial velocity until the home switch is de-activated. The activated level should be a logic 0 and the de-activated level, a logic 1.

Syntax

H *speed dir*

Arguments

$20 \leq$ speed $\leq 19{,}000$ steps/second
dir must be 1 for CCW or 0 for CW

Related Commands

F — set Initial Velocity

Programming Guidelines

Example

The system is designed so CW motion advances toward Home. The Home switch is not active and H 250 0 is executed: Motion is CW at 250 steps/second until switch is activated, then motion flips to CCW at the Initial Vel (50 steps/second) until switch is de-activated and motion stops.

Program Line	Explanation
M 10 10	set accel/decel factors
F 50	set initial velocity
H 250 0	home

The system is designed so CCW motion advances toward Home. The Home switch is not active and H 250 1 is executed: Motion is CCW until switch is activated. Motion flips to CW at the initial vel (**F**) until switch is de-activated and motion stops.

Program line	Explanation
M 10 10	set accel/decel factors
F 50	set initial velocity
H 250 1	home

I (Resolution Mode)

I *mode*

Immediate

Purpose

Selects Fixed or Variable Resolution modes. Fixed Resolution mode allows a fixed step size to be selected by the \ (Step Size) command. Of course, fine step sizes result in proportionately slower stepping rates. Variable Resolution mode allows high-speed, high-resolution indexes to be executed without compromising speed.

A mode value of 0 selects Fixed Resolution mode. Stepping proceeds at fixed resolution selected by Step Size (\).

A mode value of 1 selects Variable Resolution mode. Step resolution is automatically adjusted during an index, dependent on Initial and Final Velocity parameters. Step resolution is 20,000 pulses/rev.

Q displays the resulting Initial and Final Velocity parameters and range of step sizes to be used in subsequent absolute and incremental indexes.

Syntax

I *mode*

Arguments

mode = 0 selects Fixed Resolution Mode
mode = 1 selects Variable Resolution Mode

Programming Guidelines

Normally a preset operating parameter. Do NOT incorporate into a non-volatile memory-based program. Issue the* P *command to save changes to the operating mode.

J, B (Jump Loop, Nested)

J *addr cntr*
B *addr cntr*
Execution

Purpose

These two commands allow implementation of a double-nested loop structure. The primary **J** command and secondary **B** command can be nested. However, **J** is for jump outer loop while **B** is for jump inner loop. *addr* specifies the loop's destination address. *cntr* plus 1 is the actual number of iterations. Therefore, *cntr* must be set to the desired iterations minus 1. Use either command if only a single loop is required.

Syntax

J addr cntr
B addr cntr

Arguments

$0 \leq addr \leq 1791$
$0 \leq cntr \leq 255$ for 1 to 256 iterations

Programming Guidelines

The following example illustrates a 2 axis system, where a master 6420 controls one axis and a slave 6410 drives the other axis. The program indexes the master axis a total of 4 times; for each of these indexes, the slave axis 8 times.

Program Line		Explanation
E0		
0	F 100	
3	T 1	Outer loop begins, use J
5	+ 1000	
10	W 0	
13	T 0	enable slave axis
		Inner loop begins, use B
15	+ 1500	index 1500 steps along slave axis
20	W 0	till complete
23	W 100	wait 1 second
26	B 15 7	Repeat slave axis motion 8 times
		End of inner loop
30	J 3 3	for every master index, repeat 4 times
		End of outer loop

K (Read Input Port)

K
Immediate

Purpose

Reads user defined I/O ports. The bits are active low, so a logic 0 applied to the input port reads back as 1.

Syntax

K

Arguments

None. The bit weightings are:

Port 1 = 1	Port 5 = 16
Port 2 = 2	Port 6 = 32
Port 3 = 4	Port 7 = 64
Port 4 = 8	Port 8 = 128

Programming Guidelines

To program an I/O port bit as an input, remove the respective I/O configuration jumper. Ports 1 through 8 are configured by jumpers E3 to E10, respectively. As a consequence of the internal processor wired AND design of the I/O port, a logic 1 inadvertently written to an I/O port configured as an input over-rides the actual input state and always reads back as a logic 1. Therefore, an inactive level (logic 0) must be written to input bits.

Type **K <Enter>**. The value of P8-P1 should be displayed, with the least significant bit representing P1.

Related Commands

Y — Write Port

L (List Program)

L *addr*
Immediate

Purpose

Produces a listing of instructions starting from the specified *addr* returning up to 20 command lines. Programs are listed until a program terminator byte is encountered.

Syntax

L *addr*

Arguments

$0 \leq \text{addr} \leq 1791$

Programming Guidelines

Enter a program starting at location 0 in memory. Type **L 0**. The program should now be listed on the screen.

M (Accel/Decel Factor)

M *accel decel*

Immediate, Execution

Purpose

accel and *decel* determine acceleration and deceleration profiles. Accel/Decel ramps are determined by lookup table and are *NOT* specified in terms of dv/dt. The Initial and Final Velocity parameters are used as indicies into a lookup table to determine a range of step speeds to be applied to the drive. The time spent at any given step speed within the range is determined by *accel* and *decel*. The arguments must be in the range of 5 to 255. Values towards the low end result in high acceleration rates. Current *accel* and *decel* values can be saved in non-volatile memory by issuing the **P** command.

Syntax

M *accel decel*

Arguments

$1 \leq$ accel ≤ 255
$1 \leq$ decel ≤ 255

Programming Guidelines

Program Line	Explanation
M 100 50	accel factor 100, decel factor 50

Related Commands

F — Set Initial Velocity
V — Set Final Velocity

O (Trip Point)

O *position vaddr*

Execution

Purpose

Allows programs to vector to the location specified by *vaddr* when the position counter equals *position*. *vaddr* must be in the range of 0 to 255 and *position* in range of ±8,388,607. *position* must be a whole integer value in both Fixed and Variable Resolution modes.

Trip Point service routines generally contain I/O instructions and new trip point specifications and should not contain index, wait or other time consuming instructions. position = 0 disables this function. For the trip to occur, the main program must be actively running and not in idle mode.

Syntax

O *position vaddr*

Arguments

$-8{,}388{,}607 \leq \text{position} \leq +8{,}388{,}607$
$0 \leq \text{vaddr} \leq 255$

Programming Guidelines

Program Line	Explanation
E0	
0 Z	
1 O 5000 128	Trip at position 5000 to location 128
6 + 18000	
11 W 0	
14 G 0	Program still running
E	
E128	
128 Y 1	Activate P1 LOW
130 E	

Related Commands

T — Set Trip Point

P (Store Parameters)

P

Immediate

Purpose

Stores parameters to non-volatile memory. Values are restored to working memory upon power-up and by issuing the **A0** command.

Syntax

P

Programming Guidelines

Type **P <Enter>**. All paramters and fast memory locations 128-191 are saved to non-volatile memory in addition to:

Initial Velocity (F)
Final Velocity (V)
Ramp slope (M)
Jog Speed (^)
Trip Point (O)
Resolution Mode
Limit Switch Polarity
RS-485 Node Address
User Programs

The default mode after memory initialization is Variable Resolution Mode at Full Speed.

Whenever a change in any of these parameters or code in Fast RAM locations 128-191 is to be saved during power cycling, issue a P command.

Q (Examine Parameters)

Q

Immediate

Purpose Displays current parameters and system settings. Returns a variable number of lines depending on mode of operation. Use only in Single-User Mode.

Syntax **Q**

Programming Guidelines Type **Q <Enter>**. The screen should show the following parameter information:

M accel, decel, I = *VR* or *FR*, na = *axis name*, O = *trip pos* / *trip addr*
F = *initial vel* (*vel/stepsize*), V = *final vel* (*vel/stepsize*), (*rl = accel length*)

The *initial vel* and *final vel* are the programmed initial and final velocity values set by **F** and **V**. The actual velocities also depend on the selected *stepsize* and Resolution Mode. For instance in Fixed Resolution Mode with Half Step Size (\ 1), F=400, V=1000, the second line would appear as:

F = 400 (400/2) V = 1001 (1001/2) rl = 2

The displayed velocities may not be exactly those specified. This is a result of truncation and roundoff errors during integer division calculations. The values within the parentheses (400/2) and (1001/2) indicate the actual velocity values are 200 and 500.5 full steps/second because of the half step size selected.

Programming Guidelines In Variable Resolution Mode, Full Step Size (\ 0), F=400 and V=1000, the second line would appear as:

F = 400 (12800/32) V = 1001 (16168/16) rl = 2

The values, (12800/32) and (16168/16), indicate the actual velocity values are 400 and 1000 full steps/second and the automatically chosen step sizes are fine as 1/32 step. The \ 1 command scales velocity and the choosen automatic step sizes producing the expressions (12800/64) and (16168/32) resulting in actual velocity values of 200 and 500 full steps/second.

R (Run at Constant Velocity)

R *vel*

Immediate, Execution

Purpose

Run ramps up or down to the specified *vel*, expressed in pulses/second. In Fixed Resolution Mode, the actual speed in steps per second is determined by the current *stepsize*.

If vel = 1000 and the step resolution is set for Full Steps (200 pulses /rev), the shaft spins at 1000 full steps/sec or 300 rpm.

If vel = 1000 and the step resolution is set for 1/8 Steps (1600 pulses/rev), the shaft spins at 125 full steps/sec or 37.5 rpm.

In Variable Resolution Mode, the speed is determined by the *VelScale* factor. If *VelScale* is set by issuing \ 0 (the nominal value), and vel = 1000 the shaft spins at 1000 full steps/sec or 300 rpm.

If *VelScale* is set by issuing \ 2, and vel = 1000, the shaft spins at 250 full steps/sec or 75 rpm.

In Variable Resolution Mode, direction is determined by the sign of velocity.

Syntax

R vel

Arguments

$20 \leq |vel| \leq 19{,}000$

Programming Guidelines

Program Line	Explanation
M 10 10	set accel/decel factors
F 300	set initial velocity
R 100	accelerate to 100 steps/sec (CW)
W 1000	wait for 10 seconds
R –100	accelerate to 100 steps/sec (CCW)
W 1000	wait for 10 seconds
R 0	ramp down to 0 steps/sec

Related Commands

M — set acceleration/deceleration factors

S (Stop)

S [*arg*]

Immediate, Execution

Purpose

Stops motion with ramping deceleration specified by **M**. If the Indexer is currently running a program in execution mode or a motion command, motion ceases with ramping deceleration. If embedded in a program, an optional argument can be supplied to abort the current program in addition to stopping all motion.

If arg = 1 , motion ceases but the program continues. With arg = 0 the program terminates, placing the indexer in immediate mode.

Syntax

S [*arg*]

Programming Guidelines

Embedded in a program, stops motion and aborts, returning to idle mode.

Program Line	Explanation
S 0	or S to stop motion and abort program

Typing **S** while a program is running aborts the program and returns to idle mode.

T (Master/Slave Control)

T *enb*

Immediate, Execution

Purpose

Use when one 6420 Indexer/Drive controls motion of two axes, both at Fixed Resolution. The 6420 is the master unit controlling a slave 6410 Drive. Jumpers E12 and E13 determine if the slave unit is running synchronously with the master (identically executing index commands) or in alternating fashion (motion is executed on one axis and then the other). Power-up state is T 1.

Syntax

T *enb*

Arguments

Synchronous Operation: E12 OUT, E13 IN
enb = 1 enables step pulses to both master and slave.
enb = 0 disables step pulses to both master and slave.

Alternating Operation: E12 IN, E13 OUT
enb = 1 enables master, disables slave.
enb = 0 disables master, enables slave.

Programming Guidelines

The unit is configured for alternating operation. Alternately index each axis by :

Program Line	Explanation
T 1	enable master indexing
+ 1000	index 1000 steps at current resolution
W 0	wait till done
T 0	enable slave indexing
- 2000	index at current resolution
W 0	wait till done

To be meaningful, both units must be in Fixed Resolution mode.

U (Loop on Port)

U *addr cond*

Immediate, Execution

Purpose

Tests a single I/O port bit, P1 to P8 and jumps to the specified address *addr* if *cond* is true.

Syntax

U *addr cond*

Arguments

$0 \leq addr \leq 1791$

The cond codes are:

0 => Jump if Port 1 high	1 => Jump if Port 1 low
2 => Jump if Port 2 high	3 => Jump if Port 2 low
4 => Jump if Port 3 high	5 => Jump if Port 3 low
6 => Jump if Port 4 high	7 => Jump if Port 4 low
8 => Jump if Port 5 high	9 => Jump if Port 5 low
10 => Jump if Port 6 high	11 => Jump if Port 6 low
12 => Jump if Port 7 high	13 => Jump if Port 7 low
14 => Jump if Port 8 high	15 => Jump if Port 8 low

Programming Guidelines

Program Line		Explanation
E0		
0	M 10 10	
3	F 300	
6	V 1000	
9	U 40 1	jump if Port 1 Low
13	U 100 3	jump if Port 2 Low
17	G 9	
E		
E40		
40 + 1000		
CW 1000 steps		
45	W 0	till done
48	U 48 1	wait for release
E		
E100		
100	- 1000	
105	W 0	
108	U 108 3	
E		

V (Final Velocity)

V *vel*

Immediate, Execution

Purpose

Sets the final velocity of an @ (absolute position) or (+ -) incremental move to vel pulses/sec.

In Fixed Resolution mode, the actual speed is determined by the current *stepsize*.

If vel = 1000 and the step resolution is set for Full Steps (200 pulses /rev), the shaft spins at 1000 full steps/sec or 300 rpm.

If vel = 1000 and the step resolution is set for 1/8 Steps (1600 pulses/rev), the shaft spins at 125 full steps/sec (37.5 rpm).

In Variable Resolution mode, the speed is determined by *VelScale*. If VelScale is set by issuing \ 0 (nominal value) and vel = 1000, the shaft spins at 1000 full steps/sec or 300 rpm.

If VelScale is set by issuing \ 2, and vel = 1000, the shaft spins at 250 full steps/sec or 75 rpm.

This parameter does not affect the velocity supplied in **R** (Run at constant Velocity), or that programmed for Jog or Home operations.

Syntax

V *vel*

Arguments

$0 \leq vel \leq 19{,}000$

Programming Guidelines

Program Line	Explanation
V 1000	set final velocity for +, - and @ indexes

Related Commands

F — Set Initial Velocity

W (Wait)

W *period*

Immediate, Execution

Purpose

Waits for a specified period of time. *period* specifies the wait in terms of 10 millisecond periods. The actual wait time is period multiplied by 10 milliseconds. *period* = 0 is a special case that delays completion of the wait instruction until the end of the current motion command, such as an absolute or incremental index.

Syntax

W *period*

Arguments

0 ≤ period ≤ 65,535

Related Commands

+, - and @ indexes

Programming Guidelines

A non-zero wait period executed after issuing a motion command (absolute or incremental index) immediately starts counting down, in parallel to the motion command. If the wait period is desired after motion is complete, use W 0 followed by the actual wait command.

Program Line	Explanation
W 100	wait 1 second
+ 100000	
W 0	wait till index complete

X (Read Limits)

X *arg*

Immediate

Purpose

Returns the status of the limit, home and jog switches and the Drive Fault status. The value of *arg* specifies whether limit switch or input line information is returned.

Syntax

X *arg*

Arguments

Specifying **arg = 0** returns 1 for Limit + active, 2 for Limit – active, and 3 for both active. Bit 7 is active high if the drive faults.

Specifying **arg = 1**, returns a binary weighted value corresponding to the level of these signals:

1 => Home Input
32 => Jog - Input
64 => Jog + Input
128 => Drive Fault

Y (Write Output Port)

Y *port*

Immediate, Execution

Purpose

Writes to user defined I/O ports where *port* specifies a binary-weighted port selection bit. The port bits are active LOW (Y 1 activates Port 1).

Syntax

Y *port*

Arguments

$0 \leq \text{port} \leq 255$

Y 0 deactivates all bits producing Logic HIGHs

Y 255 activates all bits producing Logic LOWs

Related Commands

K — Read Input Port

Programming Guidelines

To program an I/O bit as an output, insert the respective jumper. Ports1 to Port 8 are configured by jumpers E3 to E10, respectively. The bit weightings are:

Port 1 = 1	Port 5 = 16
Port 2 = 2	Port 6 = 32
Port 3 = 4	Port 7 = 64
Port 4 = 8	Port 8 = 128

Avoid driving a port configured as an output by a low impedance input.

Program Line	Explanation
Y 0	Port 1 to 8 outputs off (open, pulled up)
Y 2	Port 2 output ON (sinking to ground)

Z (Zero Origin)

Z

Immediate, Execution

Purpose

Zeros position counter, normally done before a sequence of absolute moves and/or trip sequences.

Syntax

Z

Related Commands

@ — Absoloute Indexes

Programming Guidelines

Program Line		Explanation
0	Z	zero origin
1	@ 200	index 1 revolution
6	W 0	wait till done
9	W 100	wait 1 second
12	@ 0	index back to position 0
17	W 0	
20	G 0	loop

APPENDIX A SPECIFICATIONS

FIXED RESOLUTION MODE

Fixed Resolution mode offers either binary or decimal step sizes. Binary step sizes range from 200 to 51,200 pulses/rev. Decimal sizes range from 200 to 50,000 pulses/rev. All indexing is specified in terms of an integer number of step pulses at the specified resolution. Use this mode if a single 6420 indexer controls its own drive and a slave(s) 6410 drive(s).

Step Size	Minimum Speed rpm (full steps/sec)	Maximum Speed rpm (full steps/sec)	Resolution Pulses Per Revolution
Binary Steps			
Full	6 (20)	5,700 (19,000)	200
1/2	3 (10)	3,000 (10,000)	400
1/4	1.5 (5)	1,500 (5,000)	800
1/8	0.75 (2.5)	750 (2,500)	1,600
1/16	0.37 (1.25)	375 (1,250)	3,200
1/32	0.19 (0.625)	188 (625)	6,400
1/64	0.09 (0.312)	93.75 (312)	12,800
1/128	0.05 (0.156)	46.87 (156)	25,600
1/256	0.02 (0.078)	23.43 (78)	51,200
Decimal Steps			
Full	6 (20)	5,700 (19,000)	200
1/2	3 (10)	3,000 (10,000)	400
1/5	1.2 (4)	1,200 (4,000)	1,000
1/10	0.60 (2)	600 (2,000)	2,000
1/25	0.24 (0.8)	240 (800)	5,000
1/50	0.12 (0.4)	120 (400)	10,000
1/125	0.048 (0.16)	48 (160)	25,000
1/250	0.024 (0.08)	24 (80)	50,000

VARIABLE RESOLUTION MODE

The indexer varies the step size from Full to 1/256 as a function of the specified velocity/position profile. All indexing is specified in terms of a mixed integer/fractional number, with the integer portion specifying the full number of steps and the fractional portion specifying 0.01 to 0.99 decimal step resolution carried out to within 8 binary bits of precision.

Step Size	Minimum Speed, rpm (full steps/sec)	Minimum Speed, rpm (full steps/sec)	Resolution Pulses Per Revolution
Automatically chosen variable . User specifies position to within 1/100 of a step.	0.02 (0.078)	5,700 (19,000)	20,000

COMMUNICATIONS

RS-232 or RS-422/RS-485 at 9600 bits per second, 1 stop bit and no parity. The RS-485 mode supports both single axis and multi-drop, multi-axis operation.

MULTI-AXIS CAPABILITY

Multiple 6420 units may be connected to a single RS-485 bus for multi-axis operation. Another alternative is to use the Step and Direction outputs to control additional drives such as 6410s. The 6420 is designed to directly drive another 6410 drive with no glue logic. If desired, you can implement external logic controlled by any number of the user bi-directional I/O lines to control more than one drive.

PROGRAMMING

The 6420 is programmed with a simple mnemonic programming language. The unit operates in Immediate and Execution Modes. In Immediate, command line entry mode, you can interactively specify motor commands, read back status information or enter programs with an ASCII terminal or terminal emulator. The host can also read back the status of both dedicated and user-defined I/O lines connected to external switches and sensors.

In Execution Mode, previously entered programs may be executed on the 6420 to control the motor. On-board non-volatile memory offers approximately 1792 bytes for user programs. Program mnemonics vary from 1 to 5 bytes in length. Within the 1792 range, there is a 64-byte region from 128 to 191 designated as FAST memory for time critical code sections.

Input Power
24 VDC to 75 VDC. Current is motor and load dependent, usually less than motor phase current.

A 2000 µf capacitor mounted within 3 feet of the 6420 is recommended to absorb the motor regen energy.

Output Motor Phase Current
5 A_{RMS} max, % A_{PEAK} full step, 7.1 A_{PEAK} microstepping

Discrete Input Voltage
0-30 VDC max, $V_{IN} \leq 0.8$ V is a logic low and V_{IN} ³ 3.7 V is a logic high

Discrete Output Voltage
Open collector Darlington, 0-30 VDC max, 70 mA sink, $V_{SAT} \leq 1.0$ VDC.

Electrical Isolation
Indexer option power and interface signals to 6410 completely isolated. All other external inputs and outputs referenced to Indexer ground, unless otherwise specified.

Environmental Requirements

Storage temperature	-55° C to +70° C
Operating temperature	0° to 50° C ambient air
Maximum chassis operating temperature	60° C

For optimal thermal performance, mount the 6420 chassis back or side to a cooling plate or heatsink. Use a thermal pad or grease if surface is irregular. A fan or idle current reduction may be used to keep chassis below 60° C.

Convection Cooling	
with optional heatsink	Full rating (5A) at 25°C Ambient 2.5A max at 45°C Ambient
without optional heatsink	2.5A max at 25°C Ambient 1.25A max at 45°C Ambient
Humidity Range	10 to 90%, non-condensing

Adhere to the specified bus voltage range and power ratings; a heat sink may be required to prevent exceeding the temperature limit. Otherwise, unit may be damaged.

Mechanical

Dimensions	5" x 1.5" x 4.3"
Weight	1 lb nominal

Connectors

Discrete I/O	25 pin male D connector
Serial Port	9 pin male D connector
Power	3 pin PCD ELVP03100
Motor	5 pin PCD ELVP0

APPENDIX B ORDERING INFORMATION

This appendix lists 6420 part numbers and gives information on ordering.

Part	Danaher Motion Order #	Comment
Stepper Drive	6420	
Connector Kit	CK6420	25-pin D connector
		9-pin D connector
		5-pin PCD
		3-pin PCD
6420 Dialogue	904-008101-00	3 1/2 inch
User Manual	MA6420	903-642020-00
Motor Cable	SPC-*xxx*-6420	*xxx* represents length in feet; for example, SPC-005 is a cable 5 feet long. For lengths over 50 feet contact Pacific Scientific. The connectors are MS on the motor end and PCD on the drive end to connect to Pacific Scientific motors.
Heatsink	HS6420	Optional heatsink.

Danaher Motion products are available nationwide through an extensive authorized distributor network. These distributors offer literature, technical assistance and a wide range of models off the shelf for fastest possible delivery.

Danaher Motion sales engineers are conveniently located to provide prompt attention to customers' needs. Call the nearest office listed for ordering and application information or for the address of the closest authorized distributor.

Danaher Motion Customer Support

Phone: (815) 226-2222

Email: customer.service@DanaherMotion.com

Web: www.DanaherMotion.com

APPENDIX C QUICK REFERENCE

This section contains an alphabetized list of 6420 programming commands including a brief description and the operating modes where they apply. See section 7 for a comprehensive description.

Command	Description	Mode
+ steps	Incremental move +	Immediate/Execution
- steps	Incremental move-	Immediate/Execution
:axis	Selective Termination	Immediate
<addr data	Write Non-volatile Memory	Immediate
=polarity	Limit Polarity	Immediate
>addr size	Read Non-volatile Memory	Immediate
@position	Absolute move	Immediate/Execution
\step size	Stepsize VelScale	Immediate/Execution
]	Read Moving Status	Immediate
^speed	Set Jog Speed	Immediate/Execution
^C	Software Reset	Immediate
‘nextpos port	Special Trip	Execution
A opcode	Clear and Restore	Immediate
B addr cntr	Jump inner loop	Execution
C arg	Read Position Counter	Immediate
E addr	Program Mode	Immediate
ESC	Abort or Terminate	Immediate
F vel	Initial Velocity	Immediate/Execution
G addr [trace]	Go	Immediate/Execution
H speed dir	Home	Immediate/ Execution
I mode	Resolution Mode	Immediate
J addr cntr	Jump outer loop	Execution
K	Read Input Port	Immediate
L addr	List program	Immediate
M accel decel	Ramp Slope	Immediate/Execution
O position vaddr	Trip Point	Execution
P	Store Parameters	Immediate
Q	Examine Parameters	Immediate
R vel	Run at constant velocity	Immediate/Execution

Command	Description	Mode
S [arg]	Stop	Immediate/Execution
T enb	Master/Slave Control	Immediate/Execution
U addr cnd	Loop on Port	Immediate/Execution
V vel	Final Velocity	Immediate/Execution
W period	Wait	Immediate/Execution
X arg	Read Limits	Immediate
Y port	Write Output Port	Immediate/Execution
Z	Zero Origin	Immediate/Execution

APPENDIX D RAMP ALGORITHM & LOOKUP TABLE

The 6420 Indexer/Drive uses a lookup table to determine the number of steps in the velocity ramp that occur from the initial (start/stop speed) velocity to the final velocity. The lookup table contents are included at the end of this appendix.

The velocity profile is a quantized linear ramp with discrete velocities stored in a lookup table. The velocity commands are in pulses-per-second.

The algorithm begins at the exact start/stop velocity entered and runs at the next highest velocity in the lookup table. The velocity increments until it reaches the value immediately before the final velocity entered. The next velocity is the final velocity.

The number of pulses output at each velocity is determined by **M**(slope). **M** sets the number of pulses at each velocity.

For example:

M5
F300
V3000

The start/stop velocity and table velocities are:

155	562	820	1036	1227	1407	1581	1742	1905	2058
2190	2340	2472	2620	2736	2864	3004			

Five pulses are generated at each of these rates as set by **M** 5. The total ramp time from initial to final velocity is given by the sum of the times at each velocity during ramp up.

$$\text{Ramp time} = M * \sum_{\text{V=start/step velocity}}^{\text{V=Last table entry before final velocity}} {}^{1}/_{V}$$

For example, ramp time for the above is:

$$\text{Ramp time} = 5 * \left[\frac{1}{300} + \frac{1}{562} + \frac{1}{820} + \frac{1}{1036} + \frac{1}{1227} + \frac{1}{1407} + \frac{1}{1581} + \frac{1}{1742} + \frac{1}{1905} + \frac{1}{2058} + \frac{1}{2190} + \frac{1}{2340} + \frac{1}{2472} + \frac{1}{2620} + \frac{1}{2736} + \frac{1}{2864} \right]$$

DIVIDE COMMAND

The divide command (\n) modifies the ramp profile. The divide command adds more points to the velocity ramp, resulting in smaller velocity increments and smoother ramping.

All commanded velocities are divided by \n. When using the (\2) command with the previous example, the actual output pulse rate is divided by 2. The initial velocity (Fnn) is 150 pulses-per-second and the final velocity (Vnn) is 1500 pulses-per-second. The new, modified ramp time is:

Ramp time = 5 *2

To run between the same start and final velocities as the original example (300 to 3000) with (\2) command, the program parameters are:

```
\2
M 5
F 600
V 6000
```

Velocities are found from the lookup table:

155	562	820	1036	1227	1407	1581	1742	1905	2058
2190	2340	2472	2620	2736	2864	3004	3126	3225	3348
3461	3582	3690	3804	3925	4028	4137	4251	4342	4468
4568	4672	4744	4856	4974	5056	5141	5273	5365	5461
5560	5610	5715	5823	5936	5994				

The velocity ramp now consists of 46 points compared to the initial 14 without the (\2) command.

Ramp time = $5 * \left[\frac{1}{300} + \frac{1}{721} + \frac{1}{1054} + \cdots + \frac{1}{5994} \right]$

If the final velocity is below 721 sps (second speed in the lookup table) there is NO ramping associated with the move. Instead, the move is completed in one step.

Example If Initial velocity is 100 steps/sec, Final Velocity is 1000 steps/sec, acceleration factor = 120, deceleration factor = 20, the intermediate velocity points are 155, 562 and 820 steps/sec (see Profile Generator Table on the next page). During acceleration 120 steps at 100 steps/sec, followed by 120 steps each at 155 steps/sec, 562 steps/sec, 820 steps/sec, concluding with the Final Velocity at 1000 steps/sec for the duration of the index until deceleration commences.

One exception to this is if the specified duration of the index (in steps) is not long enough to allow the motor to reach the Final Velocity. The profile tops out at some intermediate point followed by the deceleration interval.

Profile Generator Look-up Table

155	562	820	1036	1227	1407	1581	1742	1905	2058
2190	2340	2472	2620	2736	2864	3004	3126	3225	3348
3461	3582	3690	3804	3925	4028	4137	4251	4342	4468
4568	4672	4744	4856	4974	5056	5141	5273	5365	5461
5560	5610	5715	5823	5936	5994	6113	6174	6301	6366
6433	6501	6606	6678	6788	6864	6942	7021	7271	7358
7447	7538	7585	7680	7777	7826	7927	7979	8084	8137
8246	8302	8416	8474	8533	8593	8714	8777	8840	8904
8969	9035	9170	9239	9309	9380	9452	9525	9600	9675
9752	9752	9830	9909	9990	10072	10155	10240	10240	10326
10413	10502	10593	10593	10685	10778	10778	10874	10971	10971
11070	11170	11170	11273	11377	11377	11592	11702	11702	11815
11815	11930	11930	12047	12166	12166	12288	12288	12412	12412
12538	12538	12538	12668	12668	12800	12800	12934	12934	13072
13072	13072	13212	13212	13356	13356	13356	13503	13503	13653
13653	13653	13806	13806	13806	13963	13963	14124	14124	14124
14288	14288	14288	14456	14456	14456	14456	14628	14628	14628
14804	14804	14804	14985	14985	15170	15170	15170	15360	15360
15360	15360	15554	15554	15554	15554	15753	15753	15753	15753
15958	15958	15958	15958	16168	16168	16168	16168	16168	16384
16384	16384	16384	16605	16605	16605	16605	16605	16832	16832
16832	16832	16832	17066	17066	17066	17066	17066	17307	17307
17307	17307	17307	17307	17554	17554	17554	17554	17554	17554
17808	17808	17808	17808	18070	18070	18070	18070	18070	18070
18340	18340	18340	18340	18340	18340	18340	18618	18618	18618
18618	18618	18618	18618	18618	18904	18904	18904	18904	18904
18904	18904	19200	19200	19200	19200	19200	19200	19200	19200
19200	19504	19504	19504	19504	19504	19504	19504	19504	19819
19819	19819	19819	19819	19819	19819	19819	19819	19819	20144
20144	20144	20144	20144	20144	20144	20144	20480	20480	20480
20480	20480	20480	20480	20480	20480	20480	20480	20480	20827
20827	20827	20827	20827	20827	20827	20827	20827	20827	20827
20827	21186	21186	21186	21186	21186	21186	21186	21186	21186
21186	21186	21186	21186	21186	21557	21557	21557	21557	21557
21557	21557	21557	21557	21557	21557	21557	21557	21557	21942
21942	21942	21942	21942	21942	21942	21942	21942	21942	21942
21942	21942	21942	21942	21942	21942	21942	21942	22341	22341

22341	22341	22341	22341	22341	22341	22341	22341	22341	22341
22341	22341	22341	22341	22341	22341	22341	22341	22341	22341
22341	22755	22755	22755	22755	22755	22755	22755	22755	22755
22755	22755	22755	22755	22755	22755	22755	22755	22755	22755
22755	22755	22755	22755	22755	22755	22755	22755	22755	22755
22755	23184	23184	23184	23184	23184	23184	23184	23184	23184
23184	23184	23184	23184	23184	23184	23184	23184	23184	23184
23184	23184	23184	23184	23184	23184	23184	23184	23184	23184
23184	23184	23184	23184	23184	23184	23184	23184	23184	23184
23184	23184	23184	23184						

SPEED ACCURACY

The 6420 Indexer generates step pulses by initializing a counter with a value that generates interrupts at approximately the desired step rate. The counter runs at a frequency of 1.2288 MHz. This value is divided by the desired step rate to yield the integer counter initialization value. Consequently, the rounding process results in reduced accuracy as speeds increase.

For example, step rates from 2498 to 2502 steps/second yield a 491 count value and result in an actual speed of 2503 steps/second. Likewise, 2503 to 2507 steps/second yield a 490 count and result in an actual speed of 2508 steps/second. Speed accuracy over the full 20-19,000 step/second range is approximately 0.72 %.

APPENDIX E APPLICATION EXAMPLES

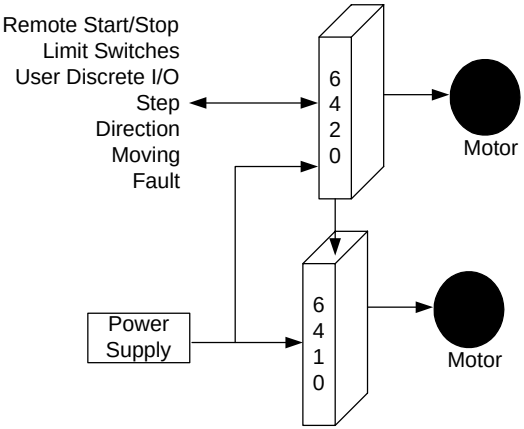
The following examples provide just a few of the applications for the 6420.

STANDALONE OPERATION

The 6420 has approximately 1792 bytes of internal, non-volatile memory for user programs. Internal programs set initial and final velocities, acceleration and deceleration rates, execute incremental, absolute and constant velocity moves, program loops, branches based on the state of an input port and write to the output port(s). In addition, a special case of the **G** instruction allows up to 16 different motion routines to be executed based on the state of the lower 4 port lines.

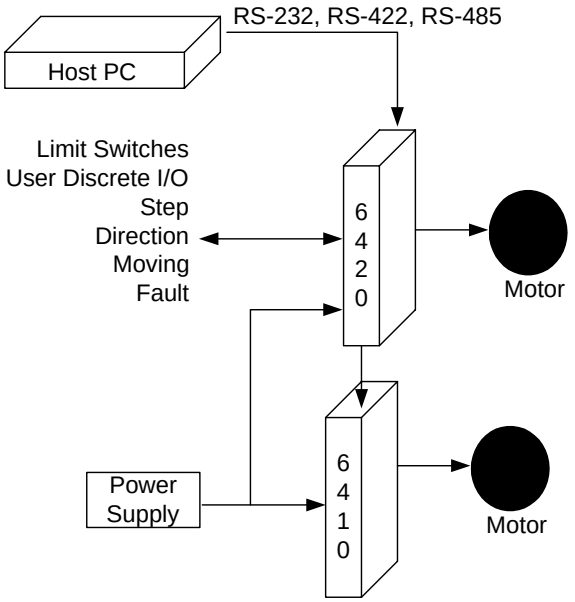
Programs are entered with the **E** command and parameters are saved with the **P** command in immediate mode. The external Remote Start and Stop start and stop program execution.

Limit switches attached to the assembly are safeguards for over-motion. A slave 6410 can be controlled by the Direction and Step lines, the Moving line can be polled for motion and the Fault line can be polled for fault conditions.



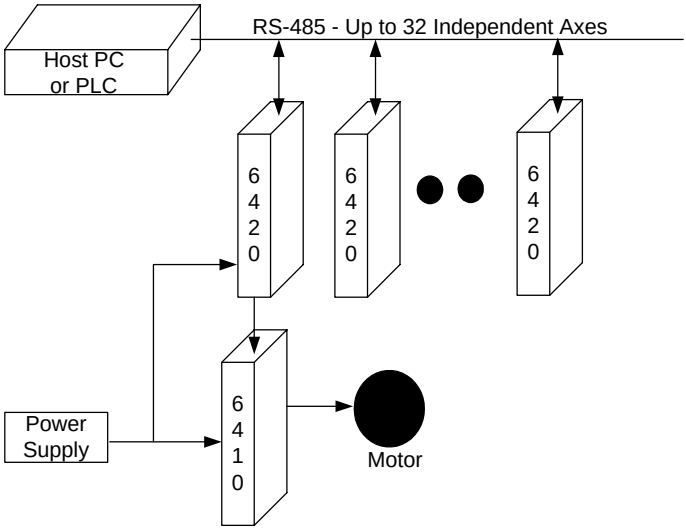
HOST OPERATION SINGLE UNIT

In this configuration, a custom host computer program issues immediate mode commands controlling all motion and parameter settings. All operations normally embodied in an on-board, non-volatile program are executed on the host with only default motion parameters stored in non-volatile memory. This allows the programming freedom and flexibility afforded by the host programming language and development environment.



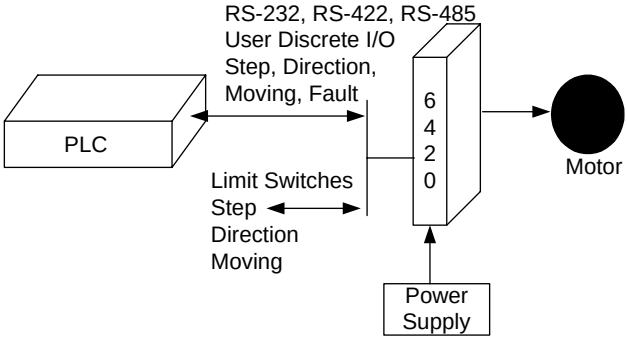
HOST OPERATION MULTIPLE UNITS

This configuration allows up to 32 independent axes to be controlled in immediate mode from a host computer or PLC. Normally, all the units operate in immediate mode, but can execute from on-board non-volatile memory. The RS-485 implementation is designed as a bus for the host computer to send commands to individual 6420s. The host issues commands to read ports on individual units, but individual 6420s cannot initiate transfers back to the host. The host is the bus master. As in other configurations, an individual 6420 can control a slave 6410.



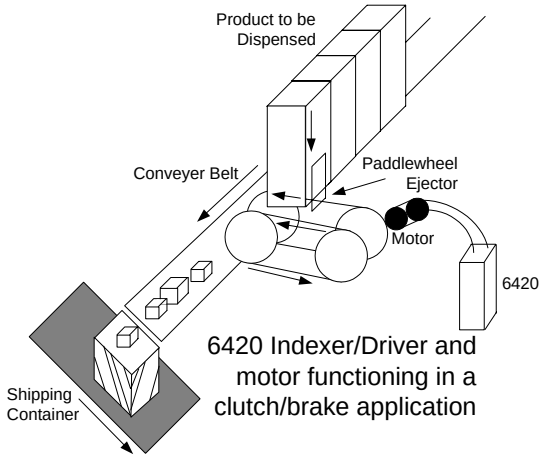
PLC BASED CONTROL

This configuration is similar to the others described above with the PLC acting as the host computer. The PLC interfaces to the parallel port lines via a RS-232, RS-422 or RS-485 interface.



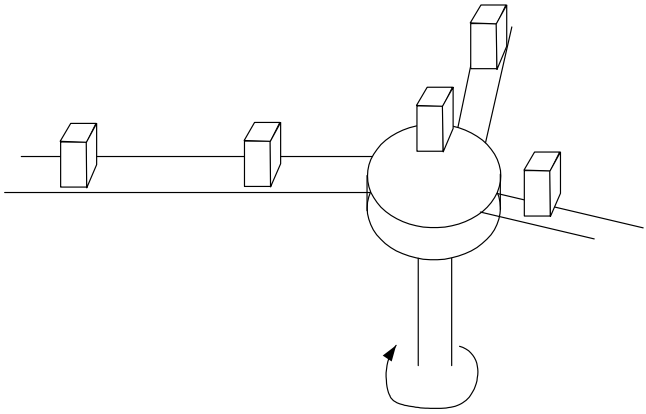
6420 DISPENSING PRODUCT ONTO CONVEYER BELT

This example shows the 6420 Indexer/Drive and motor dispensing products onto a conveyor belt and into a shipping container. The stepper motor supplies start-stop motion to a paddlewheel ejector to dispense the product. An optic sensor is used to advance the paddlewheel to the starting point. An external Start signal initiates motion to eject the product, the motion continues for one revolution until the paddlewheel is aligned for the next cycle. A host computer or an on-board non-volatile program sets the acceleration, deceleration and velocity parameters and the 6420 executes the motion.



6420 CONTROLLING INDEXER TABLE

The 6420 Indexer/Drive and motor combination easily drives an Indexing Table. The motor drives the table directly, with a belt, or through a worm gear. Use an optic sensor to indicate the starting or home position of the table and motion is executed with open-loop stepping commands.



Incremental Indexing Table

MISCELLANEOUS APPLICATION NOTES

Start-Stop Program

The following is a start-stop motion program example. The program starting at location 128 in FAST memory spins the motor until an optic sensor wired to Port 8 goes HIGH. Once this stop point is detected, the motor decelerates to a stop. The program is written such that the wait command executes in parallel with the deceleration.

If the deceleration factor is set for maximum deceleration rate (0), motion stops very quickly and dead time is about 1 second. If deceleration is set for the minimum rate (255), depending on the velocities involved, the stopping time may be several seconds possibly over-shooting the stopping point substantially and eliminating the 1 second wait command.

The optic design (reflecting or slotted type) may require some moving distance to disengage or deactivate its output. The program below runs at a constant slower speed until the sensor is cleared and then loops back to the beginning. This continuous running program is easily modified to start up with an external input applied to an I/O port.

```
128   R 1200      ;  spin the motor
131   U 140 14    ;  jump to location 140 when stop point is detected by the optic sensor.
135   G 131       ; continue polling Port 8
140   R 0         ; decelerate to 0
143   W 100       ; 1 second wait in parallel to R 0
146   U 146 14    ; loop till optics deactivated
150   G 128       ; back to beginning
```

Input Port Polling Times

Some applications may require estimates of branching times. The program below in FAST memory takes between 200 µs to 1 ms to respond to an input line. The same program in SLOW memory requires approximately 1 ms to 12 ms to respond to an input line change.

```
128   U 140 14
132   G 128
140   W 100
143   G 128
```

Using the Input Port to Select 1 of 16 Different Profiles

An external thumbwheel switch selects 1 of 16 different motion profiles. There are several different approaches to implementing this capability, but the easiest approach uses the **G** instruction to execute an indexed jump based on the state of the lower 4 input port lines.

This example initiates the indexed jump when the Remote Start input is active low. Each jump executes a particular motion and terminates, returning the 6420 to immediate mode waiting for the next Remote Start activation. At the end of motion, either a termination byte (**E**) or a branch to another location (**G**) must occur. Remember that only 16 locations are available for instructions, including the program termination character or **G** instruction.

Example

```
E 0
        0
        Any initialization code

        G 2048                  ; execute indexed jump


E       End of program here
```

This is the first profile to HOME the unit, where P[4-1] = Logic 1, 1, 1, 1.

```
E 256
        256                     H 200 1
E
```

This is the 2nd profile, where P[4-1] = Logic 1, 1, 1, 0.

```
E 272
        272                     M 40 40
                                + 800
E
```

This is the 3rd profile, where P[4-1] = Logic 1, 1, 0, 1.

```
E 288
        288                     M 100 40
                                - 200
E
```

Here is another example where an AUTOSTART program waits for Port 8 to activate the program.

```
E 1600
        1600            *
        Any initialization code
        LoopU Loop 14   ; do not continue until Port 8 inactive
                        ; Port 8 must now be inactive high
        WlowU Wlow 14   ; do not continue until Port 8 active low
        G 2048          ; execute indexed jump
E       End of program here
```

This is the first profile to HOME the unit, where P[4-1] = Logic 1, 1, 1, 1.

```
E 256
        256             H 200 1
                        W 0
                        G Loop
E
```

This is the 2nd profile, where P[4-1] = Logic 1, 1, 1, 0.

```
E 272
        272             M 40 40
                        +  800
                        W 0
                        G Loop
E
```

This is the 3rd profile, where P[4-1] = Logic 1, 1, 0, 1.

```
E 288
        288     M 100 40
                -  200
                W 0
                G Loop
E
```

Since the jump table is encoded as straight binary rather than grey-coded, set the 4 lower bits first followed by a separate activation signal. Otherwise, if you attempt to set up a continuous loop where the 4 input lines may change state while the G instruction is executing, the program may not jump to the desired profile.

APPENDIX F ASCII CODES

ASCII Code Result	ASCII Code Result	ASCII Code Result	ASCII Code Result
0 ^@ NUL	32	64 @	96 ‘
1 ^A SOH	33 !	65 A	97 a
2 ^B STX	34 \	66 B	98 b
3 ^C ETX	35 #	67 C	99 c
4 ^D EOT	36 $	68 D	100 d
5 ^E ENQ	37 %	69 E	101 e
6 ^F ACK	38 &	70 F	102 f
7 ^G BEL	39 ‘	71 G	103 g
8 ^H BS	40 (	72 H	104 h
9 ^I HT	41)	73 I	105 i
10 ^J LF	42 *	74 J	106 j
11 ^K VT	43 +	75 K	107 k
12 ^L FF	44 ,	76 L	108 l
13 ^M CR	45 -	77 M	109 m
14 ^N SO	46 .	78 N	110 n
15 ^O SI	47 /	79 O	111 o
16 ^P DLE	48 0	80 P	112 p
17 ^Q DC1	49 1	81 Q	113 q
18 ^R DC2	50 2	82 R	114 r
19 ^S DC3	51 3	83 S	115 s
20 ^T DC4	52 4	84 T	116 t
21 ^U NAK	53 5	85 U	117 u
22 ^V SYN	54 6	86 V	118 v
23 ^W ETB	55 7	87 W	119 w
24 ^X CAN	56 8	88 X	120 x
25 ^Y EM	57 9	89 Y	121 y
26 ^Z SUB	58 :	90 Z	122 z
27 ^[ESC	59 ;	91 [	123 {

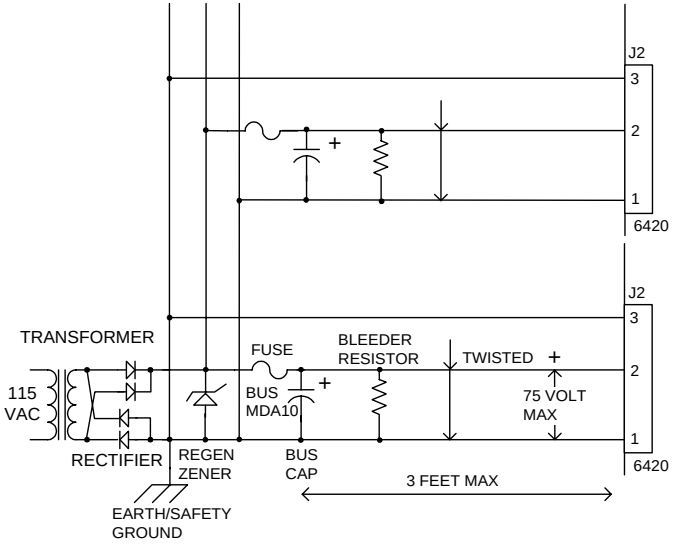
ASCII Code Result	ASCII Code Result	ASCII Code Result	ASCII Code Result
28 ^\ FS	60 <	92 \	124 |
29 ^] GS	61 =	93]	125 }
30 ^^ RS	62 >	94 ^	126 ~
31 ^_ US	63 ?	95 _	127

APPENDIX G POWER SUPPLY CONSIDERATIONS

BRIDGE, CAPACITOR POWER SUPPLY

The figure below shows the full-wave-bridge, capacitor-input configuration most commonly used to power one or more 6420 drive modules. A single transformer provides isolation and transforms the AC input voltage to a level that, when rectified, provides the desired DC bus voltage. Fuse between the rectifier and individual bus capacitors. This allows fuse size to be based upon the current requirements of a single module to provide the greatest protection. The capacitors must be connected to the 6420 DC+ and DC- inputs using twisted pairs no longer than three feet in length as shown to control winding inductive effects. A regen clamp to absorb power transferred from the motor to the 6420(s) is sometimes required. This section provides selection guidelines for the power supply components.

Block Diagram



Power supply design must insure that the voltage between J2-2 and J2-1 never exceeds 75 volts under any conditions. These conditions include high line voltage, transformer regulation effects, voltage spiking due to current switching within the module and regeneration. Failure to do this results in permanent damage to the 6420.

LINE TRANSFORMER SELECTION

Primary Voltage And Frequency Rating

Make sure the transformer is guaranteed to operate at the highest line voltage combined with the lowest line frequency that will ever be used to power your system. Failure to do so can result in saturation, large current increases and winding failure.

Secondary Voltage Rating

Maximum motor speed performance is achieved by using as high a motor supply voltage as possible without ever exceeding 75 volts. Lower voltages can also be used as long as the voltage is greater than the minimum specified value of 24 volts, but motor torque drops more rapidly as speed increases.

The peak bus voltage (excluding any spiking due to current switching in the drive module or any regeneration effects) is approximately equal to:

(**1.414 * Actual** Secondary rms voltage) - 1.5

This assumes a 0.75 volt drop across each rectifier diode. To insure this, as well as to discharge the bus capacitor when AC power is removed, place a bleed resistor across each bus capacitor as shown.

For example, the secondary RMS voltage is 40 VAC, the peak bus voltage is 1.414 * 40 - 1.5 = 55 volts. A transformer with 115 VAC primary and 40 VAC secondary would produce 55 volts peak bus voltage under nominal line conditions and at rated loading. However, if the line voltage increases 10% the peak bus voltage increases to: (1.414 * 1.1 * 40) - 1.5 = 60.7 volts at rated transformer loading.

Load regulation must also be accounted for when selecting the transformer. Transformers are designed to produce their specified secondary voltage when loaded by their rated current. **For currents less than rated, the secondary voltage increases**. Signal Transformers give the following load regulation data for its line of rectifier transformers[1]:

VA Rating	Load Regulation
1 - 100	10%
100 - 350	8%
> 500	5% or less

[1] The VA product is obtained by multiplying the specified secondary voltage (V_{RMS}) by the rated secondary current (A_{RMS}). For example, a 24 VAC transformer with a rated secondary current of 1 amp has a VA of 24.

This means that the secondary voltage of a 100 VA transformer will increase 10% over the specified voltage if the load current is reduced from rated current to zero. Since the stepper drive(s) might sometimes be disabled, the full regulation effect as well as maximum line voltage should be considered when selecting the transformer.

Based on these considerations, the table below gives the highest allowable rated secondary voltage when using a line with +10% voltage tolerance:

Transformer VA Rating	Maximum Rated Secondary Voltage
1 - 100	44.7 VAC
100 - 350	45.5 VAC
> 500	46.8 VAC

Current Rating

The average current load of the 6420 is a function of the motor used as well as motor speed and torque. To optimize the power supply design, the supply current is measured using a DC current meter when the motor is producing the highest shaft power. If it is difficult to make this measurement, assume the maximum average load current equals the selected phase current. Thus, if the DIP switch is set for 5 A_{RMS}, assume the maximum average power supply current is 5 amps.

The average transformer secondary current equals the sum of the average currents for all 6420s powered by the supply. Because the transformer supplies pulses of current to charge the bus capacitor(s) on the other side of the diode bridge, the A_{RMS} is higher than the average current. The transformer should have a rated secondary A_{RMS} of at least 1.8 times the average current.

For example, with a transformer used to supply three 6420 drive modules, each set for 5 A_{RMS} should have a rated secondary A_{RMS} of 1.8 * (5 + 5 + 5) = 27 amps or greater.

Do not significantly oversize the transformer as this increases rectifier surge current during turn on, as well as capacitor ripple current.

RECTIFIER DIODE SELECTION

Voltage Rating

For the bridge rectifier configuration shown, the peak inverse voltage (PIV) equals 1.414 times the secondary V_{RMS}. For example, a 40 V_{RMS} secondary develops 1.414 * 40 = 56.6 PIV across the rectifier diodes. To allow for line variation and spiking, allow at least a 50% safety factor in the diode rating. Therefore, the PIV rating of the rectifier diodes should be at least twice the rated secondary V_{RMS}.

Current Rating

Since each diode conducts only on alternate cycles, the average diode current is half the supply's average DC current load on the supply. When power is first applied, there is a surge of current to charge the capacitor(s) that must be less than the diode's peak one cycle surge current (IFSM) rating. Typically, diodes are chosen with an average current rating of at least twice the average current load of the supply. It is often advisable to select diodes with an even greater average current rating because they have lower thermal resistance between junction and case and reduce heat sinking requirements. It is good design practice to limit the maximum junction temperature to 125°C. Test to insure the power-on surge current is within the diode's IFSM rating.

CAPACITOR SELECTION

The table below gives the minimum bus capacitance value for a single 6420 as a function of the current setting and bus voltage. These values give approximately 10% peak-to-peak ripple voltage with a 60 Hz line (increase capacitor values by 20% for use with a 50 Hz line).

Current Setting	30 Volt Bus	50 Volt Bus	70 Volt Bus
5.0	14,000	8300	6000
4.375	12,000	7300	5200
3.75	10,000	6300	4500
3.125	8700	5200	3700
2.5	6900	4200	3000
1.875	5200	3100	2200
1.25	3500	2100	1500
0.625	1700	1000	740

Bus Capacitance in Micro farads

Ripple Current Rating

The bus capacitor's 120 Hz ripple current rating should equal or exceed the 6420's current setting. The capacitor's working voltage rating must exceed the maximum bus voltage under all line, load, and regen conditions. Select a capacitor rated for at least 1.3 times the nominal bus voltage.

For example, suppose a 6420 is operating at 70 volts and is set for 5 A_{RMS} motor current. Assuming a 60 Hz line, use a bus capacitor of 6000 micro farads. The capacitor should have a 120 Hz ripple current rating of at least 5 A_{RMS} and a working voltage of at least 1.3 * 70 = 91 volts.

The bus capacitor should be connected to the 6420 using a twisted pair, no longer than 3 feet in length.

FUSE SELECTION

The BUS MDA 10 slow blow fuse or equivalent is recommended when the 6420 is set for 5 smps. Fuses from the same family with proportionally lower current rating can be used with lower current settings.

REGENERATION CONSIDERATIONS

The motor power supply voltage can be "pumped up" when the motor and load are decelerated by the drive. In effect, the motor becomes a generator converting mechanical energy stored in the spinning motor and load inertia into electrical energy. If the mechanical energy is less than the losses in the drive and motor, the supply voltage does not increase. If the mechanical energy is greater than these losses, the supply voltage increases (pumps up).
The mechanical energy of a spinning inertia is given by:

$$E = 3.87 * 10\text{-}5 * J * S2$$

where: E = kinetic energy (joules)
J = inertia in oz-in-sec^2
S = speed in rpm

Final Voltage

If this energy is converted to electrical energy in the form of charge on the bus capacitor(s), the voltage is:

$$V = \sqrt{V_O^2 + \frac{2E}{C}}$$

where: V is the final voltage (after energy transferred to capacitor(s)
Vo is the initial voltage
C is the total capacitance in farads
E is the initial kinetic energy in joules

For example, if an unloaded E34 motor (rotor inertia = 0.035 oz-in-sec^2) is rotating at 1500 rpm, the stored energy is:

$$3.87 * 10^{-5} * 0.035 * 15002 = 3.0 \text{ joules}$$

If all this energy is transferred to a 6800 mf capacitor, initially charged to 70 volts, the voltage on the capacitor after the transfer is equal to 76 volts.

This exceeds the volt maximum specification of the 6420 drive.

In practice, most or all the kinetic energy is dissipated in the motor windings or in the drive's power circuitry so voltage pump-up is often not a problem. However, in systems running at high speeds and having large load inertia, the voltage might be pumped up significantly and circuitry must be added to insure that the 75 volt limit is never exceeded.

Consider regeneration effects in the presence of high line conditions.

To find out if regenerative energy is a problem, run the system while monitoring the supply voltage with a storage oscilloscope. Alternatively, a simple peak detector made from a diode and a capacitor can be attached to the bus and the peak voltage measured using a digital voltmeter. Start the system with slow deceleration rates and monitor the motor power supply to see if the voltage rises during deceleration. Slowly increase the deceleration rate (shorten the deceleration time) while monitoring the voltage. If regeneration causes the supply voltage to exceed 75 VDC peak, a clamping circuit is required.

Consider the effect of high line voltage when evaluating this test.

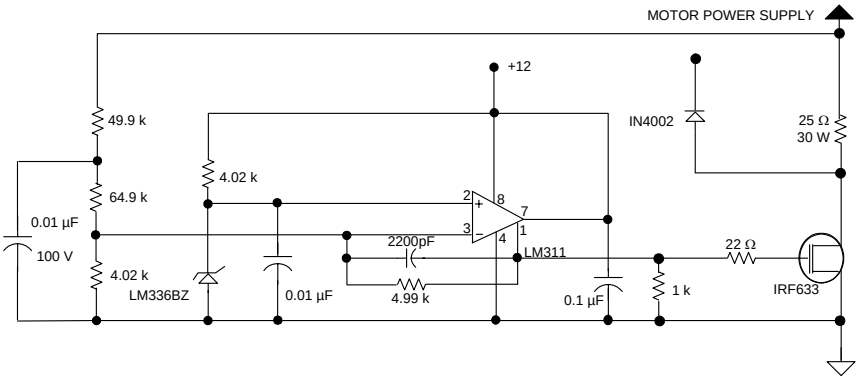
Clamping Circuit

If a clamp is required, a power zener diode can be used as shown in the figure. The maximum zener clamp voltage must not exceed 75 volts.

If a clamp is required, the transformer's secondary voltage must be re-checked to insure that the minimum clamp voltage is not exceeded under high line and low load conditions when there is no regeneration. Otherwise, the zener might overheat and fail.

To determine the required diode power rating, start with a 5-W device and monitor the zener current with a current probe. Power (in watts) is the average current (in amps) times the zener voltage. Estimate the average current from the oscilloscope trace and compute the power. Select a zener rated slightly higher than the measured power.

If the average power is too high to be conveniently dissipated in a zener diode, the active voltage clamp circuit shown below can be used instead. Power is dissipated in the 25Ω, 30W resistor if the Motor Power Supply voltage exceeds 75 volts.



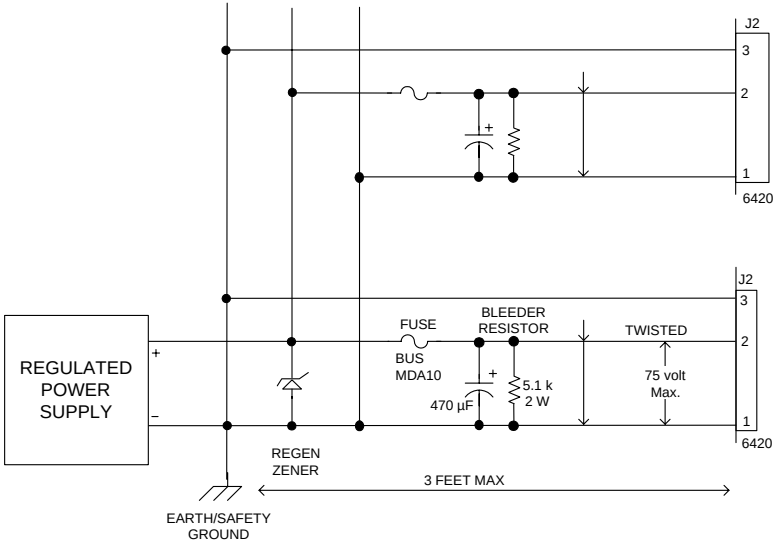
POWERING THE 6420 FROM A REGULATED SUPPLY

Certain precautions should be taken when powering the 6420 drive from a regulated power supply. The 6420's bipolar chopper output stage draws current from the DC supply in the form of pulses with fast rise and fall times. This may be a problem for some regulated supplies designed to drive loads having relatively constant or slowly varying current drain. If a regulated supply is used and problems are encountered, place a 470 µf capacitor across the DC+ and DC- lines between the power supply and 6420. Ideally, this capacitor is located close to the 6420 drive, but it can be located near the power supply and connected to the 6420 with a twisted pair no longer than 3 feet in length. The capacitor should have a 20 kHz ripple current rating of at least the 6420's current setting and a voltage rating of 1.3 times the nominal bus voltage.

A second precaution involves regenerated power. Regulated supplies are usually not designed to absorb power. This might cause their output voltage to rise during regeneration and lead to power supply and/or 6420 damage.

6420(S) POWERED BY REGULATED SUPPLY

The next figure demonstrates powering the 6420 from a regulated supply where both an external capacitor and regenerated power dump circuit are required. The recommended fusing is also shown.



INDEX

-
  negative incremental move, 43
:
:StepSize, VelScale, 44
@
  absolute move, 40
]
  read move status, 47
^
  set jog speed, 39
^C
  reset software, 46
‘
  trip and output, 48
+
  positive incremental move, 42
<
  write memory, 47
=
  limit switch
    polarity, 49
>
  read memory, 46
6420
  commands
    initialization, 29
    utility, 29
  communication, 2
  connections
    serial port, 32
  controlling a 6410, 18
    alternating operation, 19
    synchronous operation, 19
      E12 IN, E13 OUT, 19
  default settings, 19
    drive, 19
    drive board, 20
    E1, 21
    E10, 22
    E11, 21
    E12, 22
    E13, 22
    E2, 21
    E3, 22
    indexer, 20
    indexer board, 21
    jumper settings, 21
  dialogue, 31
    installing, 32
  dialogue floppy, 31
  drive features, 3
  execution mode, 28
  indexer features, 4
  inspecting, 5
  installation, 5
    testing, 23
  keyboard commands, 32
  maintenance, 25
  memory, 29
    FAST RAM, 30
    map details, 30
    user programs, 29
  mounting, 5
    dimensions, 6
  power up, 23
  program
    getting started, 31
  programming, 27
    AUTOSTART, 27, 28
    immediate mode, 27
    initialize parameter, 29
    instructions, 39
    Instructions, 28
    motion control, 29
    program control, 29
    REMOTE START, 27
  Programming
    symbolic labels, 36
  terminal emulator, 33
  troubleshooting, 25, 26
  unpacking, 5
6420 Definition, 1

A
clear and restore, 50
Abort, 45
Accel
factor, 60
Address translation, 37

B
jump nested loop, 57
Block Diagram, 2

C
read
position counter, 51
Capability
multi-axis, 74
Clear, 50
Commands
keyboard, 32
Communication
RS-232, 2
RS-422, 2
RS-485, 2
serial protocol, 2
Communications
specifications, 74
Connections
serial port, 32
Connector
J3, 7
specifications, 76
Control
master/slave, 66
Counter
read position, 51

Decel
factor, 60
Download, 33

E
edit program, 52
Edit
program, 52
Editor, 34
Environment
specifications, 75
ESC, 45
Examine
parameter, 63

F
initial velocity, 53

G
go, 54
Go, 54

H
home, 55
Home, 55

I
resolution mode, 56
I/O
connecting cables, 6
connection diagram, 7
Indexer
language, 36
INIT serial port, 35
Input
read port, 58
Input power
specifications, 75
Input voltage
specifications, 75
Isolation
specifications, 75

J
jump nested loop, 57
J2
power connection, 10
cable diagram, 11
mating connector, 10
J3
motor connection, 7
4-lead cable, 8
4-lead diagram, 8
8-lead parallel cable, 10
8-lead parallel cable diagram, 10
8-lead series cable, 9
8-lead series cable diagram, 9
building a 4-lead cable, 8

building an 8-lead parallel cable, 10
building an 8-lead series cable, 9
J4
series port connection, 11
baud rate, 11
mating connector, 11
pin designations, 12
pinouts, 11
single-unit RS-232 connection, 12
single-unit RS-422 connection, 12
single-unit RS-485 connection, 13
J5
dedicated I/O designations, 16
discrete I/O connection, 13, 15
block diagram, 14
pin designations, 14
port designations, 14
input diagram, 15
input interface, 17
output diagram, 15
output interface, 18
Jog
set speed, 39
Jump
nested loop, 57

K
read input port, 58
Keyboard
commands, 32

L
list program, 59
Label
generation for address, 38
Labels
address translation, 37
symbolic, 36
Language, 36
Limit switch
polarity, 49
Limits
read, 70
List program, 59
Loop
jump nested, 57
on port, 67

M
accel/decel factor, 60
Master
control, 66
Mechanical
specifications, 76
Memory
read, 46
write, 47
Mode
execution, 28
fixed resolution, 2, 73
immediate, 27
resolution, 56
variable resolution, 2, 3, 74
Move
absolute, 40
negative incremental, 43
positive incremental, 42
read status, 47

O
trip point, 61
Output, 48
write port, 71
Output current
specifications, 75
Output voltage
specifications, 75

P
store parameters, 62
Parameter
examine, 63
store, 62
Polarity
limit switch, 49
Port
loop, 67
write output, 71
Program
edit, 52

list, 59
Programming
specifications, 74
symbolic labels, 36

Q
examine parameters, 63

R
run at constant velocity, 64
Read
input port, 58
limits, 70
memory, 46
move status, 47
position counter, 51
Reset
software, 46
Restore, 50
Run
constant velocity, 64

S
stop, 65
Serial port, 32
Slave
control, 66
Software
reset, 46
Specifications
communications, 74
connector, 76
electrical isolation, 75
environment, 75
fixed resolution mode, 73
input power, 75
input voltage, 75
mechanical, 76
multi-axis, 74
output current, 75
output voltage, 75
programming, 74
variable resolution mode, 74
Speed
set, 39
StepSize, 44
Stop, 65
Store
parameter, 62
Syntax checker, 33
System
components, 4

T
master/slave control, 66
Terminal emulator, 33
Termination
selective, 47
Trip, 48
point, 61

U
loop on port, 67
UL, 3
Upload, 33
Utility
download, 33
editor, 34
init serial port, 35
syntax checker, 33, 37
upload, 33

V
final velocity, 68
Velocity
final, 68
initial, 53
run at constant, 64
VelScale, 44

W
wait, 69
Wait, 69
Warranty, 4
Write
memory, 47

X
read limits, 70

Y
write output port, 71

Z
zero origin, 72
Zero, 72